Erasmus Plus Project
2016-1-PL01-KA219-026303_2

"Moving forward with key competences"

Physics experiments to be used in class

Sommario

Topic 1: Study of magnetic field – student worksheet

Main issues: magnets, *magnetic pole, magnetization, magnetic field, magnetic field lines, iron filings, magnetic polarity, magnetic needle, compass*

Hypothesis: *Does different kind of magnet influences the shape of the magnetic field?*

Experience description: *Observation of magnetic field generated around magnets.*

Task 1. What kind of objects attracts the magnet?

You have at your disposal: chalk, coin, crayon, office clip, eraser, nail, polystyrene, sheet of paper.
Follow: Check which of the prepared objects are attracted by the magnet. Note the results in the table below.

Object	**Magnet**	
	Attracts	**Does not attract**
Chalk		
Coin		
Crayon		
Office clip		
Eriser		
Nail		
Polystyrene		
Sheet of paper		

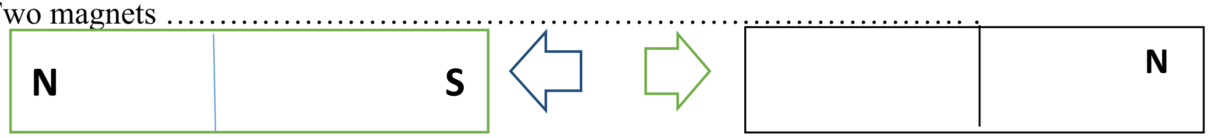
Student's copy

Task 2. How do magnets affect each other?

You have two bar magnets at your disposal.

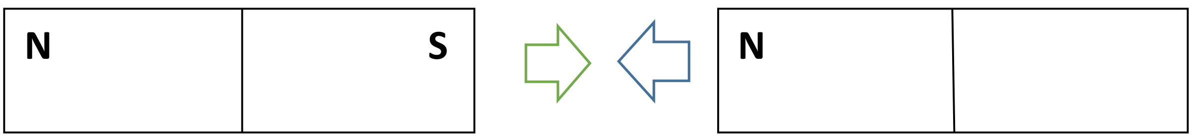
Follow: Put close the magnets with different poles. Complete the following drawings: sign and color the poles of the magnets and dice the corresponding arrows.

1) Two magnets ………………………………………………………………… .



2) Two magnets ………………………………………………………………… .

3) Two magnets ………………………………………………………………… .



Conclude and supplement the sentence.

The same kind of magnets poles ……………………………………….. each other and a different kind of magnets poles ……………………………… each other .

Write down what kind of magnets poles it is.

………………………………………………………………… ……………………………………………………………………

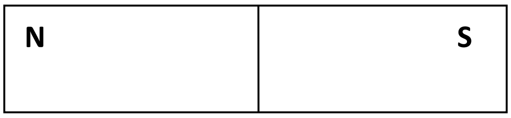
Student's copy

Task 3. How does the picture of magnetic forces arise?

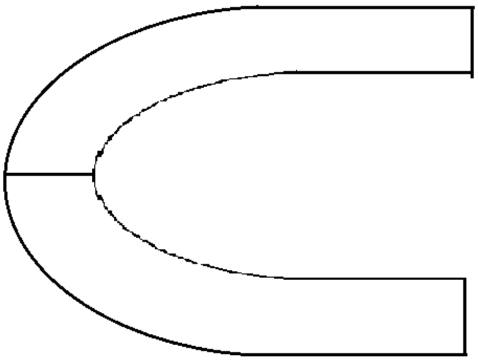
Follow: Draw the way the iron filings are arranged in the plastic box under which the bar magnet is located.

The iron filings system shows the arrangement of magnetic field forces around the magnet..

A) Arrangement of the magnetic field line of the bar magnet

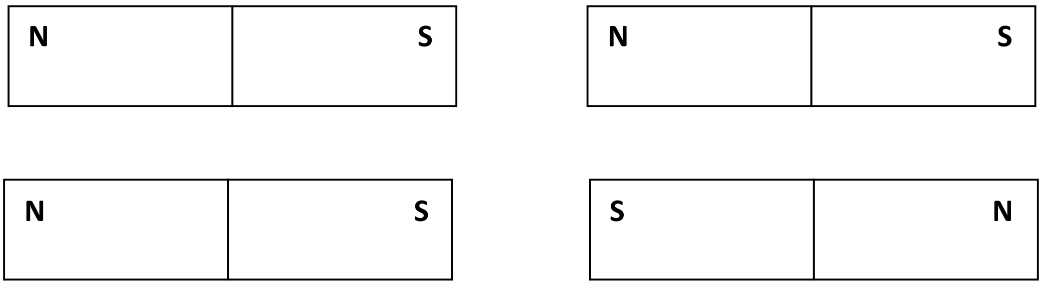


B) Arrangement of the magnetic field line of the horseshoe magnet



C)

Arrangement of the magnetic field line of the two bar magnets



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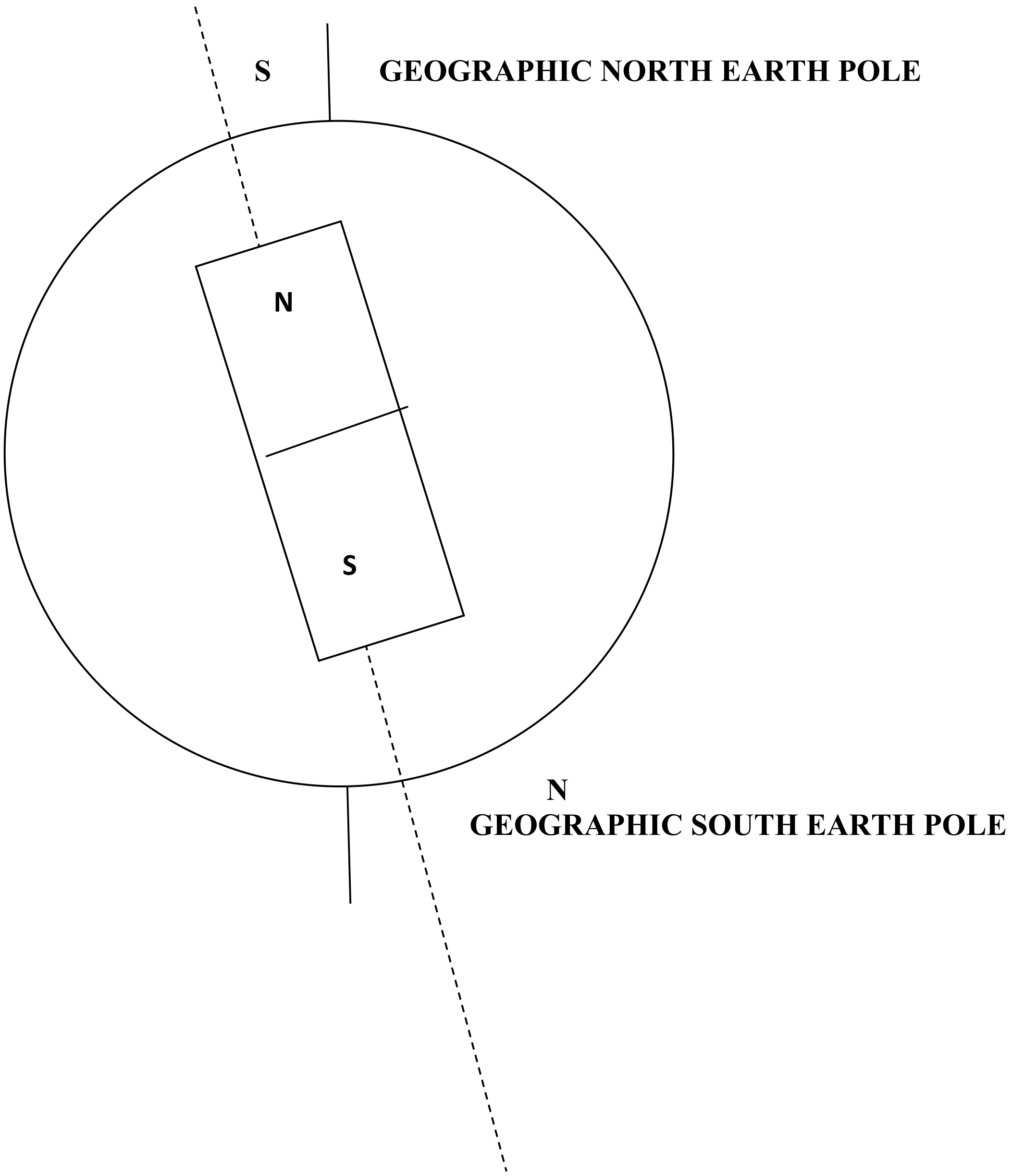
Task 4. Draw lines of magnetic field of the Earth.



Student's copy

Topic 1: Study of magnetic field – teacher worksheet

Goals

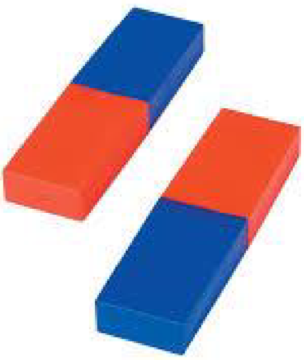
Investigations of the magnetic fields produced by different shapes magnets and influence of the magnetic field on the matter

Operational goals
Students:
- can show and call the magnetic poles
- know how two bar magnets interact when facing each poles
- know that every piece of the magnet becomes a new magnet
- know what kind of materials can be magnetized
- draw field lines of magnets
- know how to determine the direction of magnetic field lines
- know how to determine the direction of the magnetic field of the Earth

Methods
- a small conversation with students (basic questions and answers)
- students do experiments

Forms of work
- in groups
- individual

Educational aids
- worksheets
- experimental set (bar magnets, horseshoe, magnetic needles, boxes with iron filings, compass, rubber, polystyrene foam, nails, chalk, coins, pencils, paper clips, paper)


Teacher's copy

Lesson plan:

1. Presenting the topic.
   The teacher asks pupils a few questions and leads a short discussion: - What do you know about magnets? - Do you know where the name of a magnet comes from? - Do you know where magnets are used?

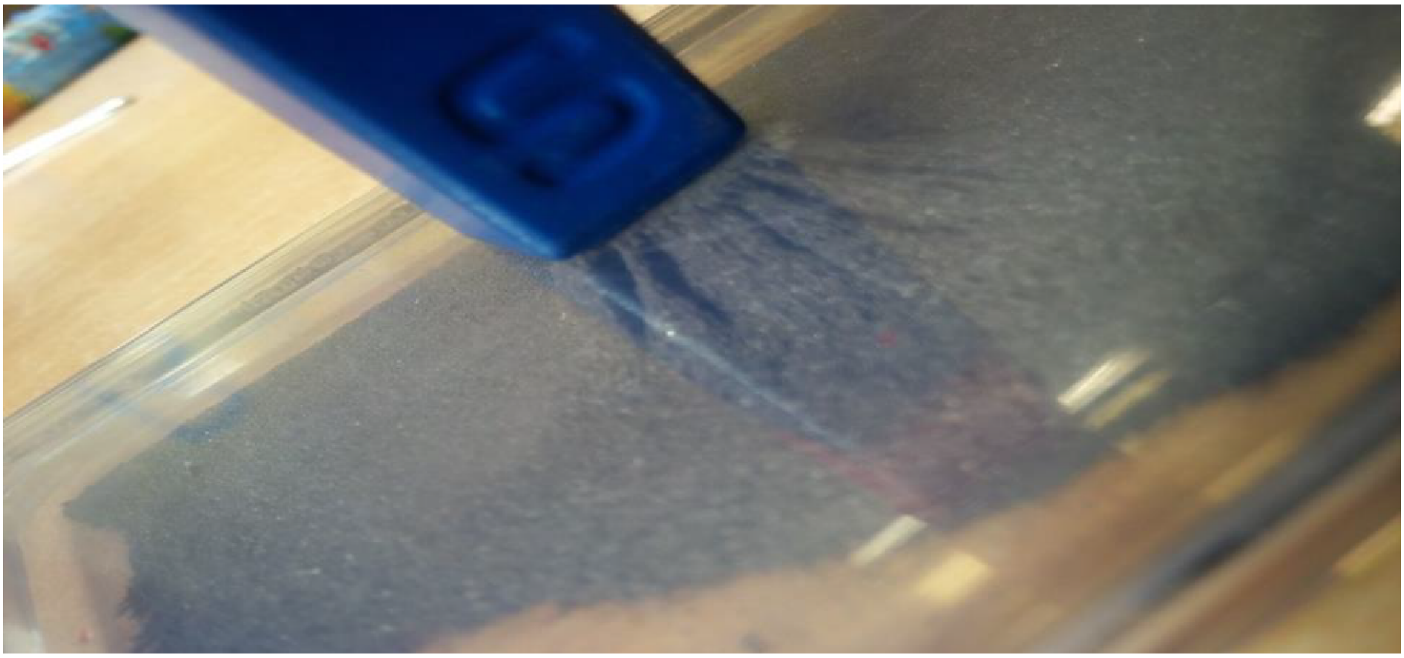
2. The experiment:

➢ The teacher reminds some information about types of previously known fundamental interactions (gravitational, electrostatic);
➢ The teacher shows the students a new kind of interaction that is magnetic forces and performs a few experiments.
➢ Pupils are divided into groups of two
➢ The teacher gives away the worksheets and the experimental sets to everyone
➢ Students work in a group with sets and fill in the worksheets

3. Summary of the lesson

➢ Teacher sums up the news on the poles of magnets:
o Every magnet has two poles: North (N) and South (S) which cannot be separated
o The same kind of magnets poles repel each other (NN or SS)
o A different kind of magnets poles attract each other (NS)
o In everyday life, magnetic fields are most often encountered as a force created by permanent magnets, which pull on ferromagnetic materials such as iron, cobalt, or nickel, and attract or repel other magnets. Magnetic fields are widely used throughout modern technology, particularly in electrical engineering and electromechanics.
o Magnetic field is represented by so-called magnetic field lines
o The Earth produces its own magnetic field, which is important in navigation, and it shields the Earth's atmosphere from solar wind.

Teacher's copy

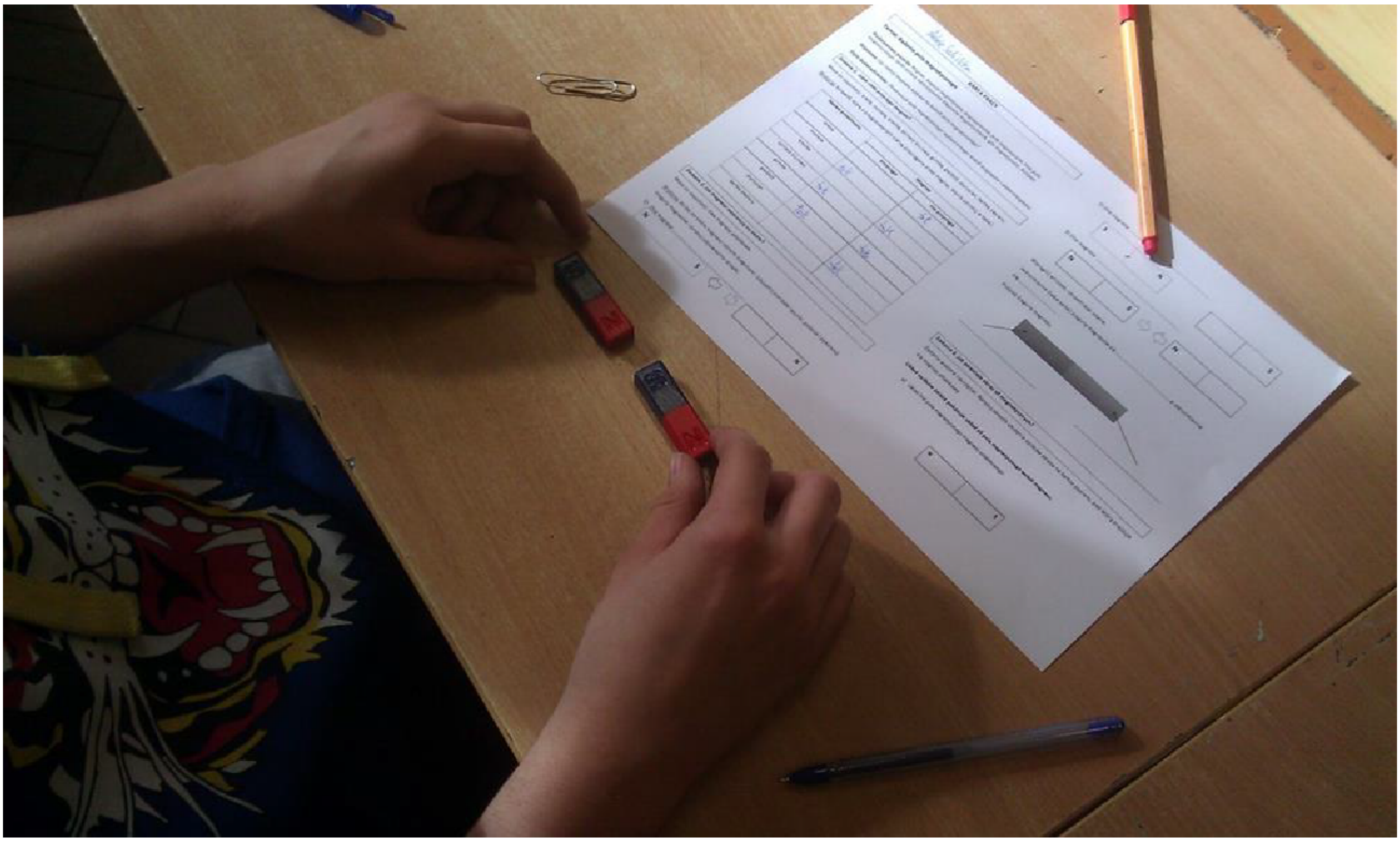


Teacher's copy

Physics experiments to be used in class

Teacher's copy

Physics experiments to be used in class



Teacher's copy

Physics experiments to be used in class

Topic 2: Experimental verification of the principle of momentum – Student Worksheet

Experiment 1.

a car – the phenomenon of jet force

Educational aids: balloon, toy car, a straw, adhesive tape.




Carrying out the experiment:

1. Blow the air into the balloon and let it off – how does it move?
2. Stick a straw to a toy car with the adhesive tape and tie a balloon to a straw with a rubber band. Inflate the balloon. Put the toy car on the table and let it go.
   What happens with the car? Which direction does it take? Why?

   Answers to the questions:
   1. ____
      ____
      ____
   2. ____
      ____
      ____

Student's copy

Experiment 2.

a bottle – the phenomenon of jet force

Educational aids: plastic bottle, methylated spirit, a holder for a bottle made of a wire.

Carrying out the experiment:

1. Pour a little methylated spirit into a plastic bottle.
2. Close it with a top in which a hole was made – it will act as a rocket.
3. Put the bottle on the special holder with the top down.
4. Heat the top with the lighter. What happens with the bottle? Why? Why is it similar to the launching of the rocket?

   Answers to the questions:

   1. ____
   ____
   ____
   ____

Student’s copy

Topic 2: Experimental verification of the principle of momentum – Teacher Worksheet

Goals

Students know the principle of momentum and can test it empirically

Operational goals:

Student:

- ✓ can use the principle of momentum for collisions
- ✓ can supports air path with electronic clock,

Main knowledge of students:

Student:

- ✓ knows the concept of momentum and its unit,
- ✓ can form the principle of momentum,
- ✓ can describe the elastic collisions,
- ✓ can describe non-elastic collisions,
- ✓ knows the difference between elastic and non-elastic collisions,
- ✓ knows the equations of final velocities of colliding objects,
- ✓ can prepare the air track, choose the elements that are needed to make the experience

Method:

- ✓ **discussion**, dialogue with students (questions and answers), and the virtual experiment,
- ✓ **exercises** – make an experiment that allows to verify the validity of the principle of momentum

Educational aids

- ➢ air track
- ➢ worksheets
- ➢ balloon, toy car, a straw, adhesive tape, a plastic bottle, methylated spirit,

Teacher’s copy

Lesson plan:

1. Presenting the topic.

Teacher:

- ➢ asks questions about the momentum, equation and units,
- ➢ carries out the virtual experiment with the students – a take-off of the rocket- (drawing it on the blackboard)

2. The experiment:
   - ➢ Teacher supervises the activities of the students during the experiment and helps with the experiment.
   - ➢ Students do some independent experiments using the air track:
     - wagons of equal mass, equipped with resilient bumpers are set at the ends of the track and collide with each other,
     - wagons with different masses (one is two times heavier than the other), equipped with resilient bumpers are set at the ends of the track and collide with each other. The distance of the heavier wagon is two times longer,

Teacher's copy

- wagons of equal mass, equipped with resilient bumpers are set in the middle of the track. Wagons jump off and simultaneously reach the ends of the track,
- wagons with different masses (one is two times heavier than the other), equipped with resilient bumpers are set in the middle of the track but the distance of the heavier wagon is two times longer,
- in every cases students read the times and distances before and after the collision. They write down the results.

➢ Students do two more experiments on the principle of momentum (the jet force of a car and a bottle) - worksheet.

Teacher's copy

Teacher's copy

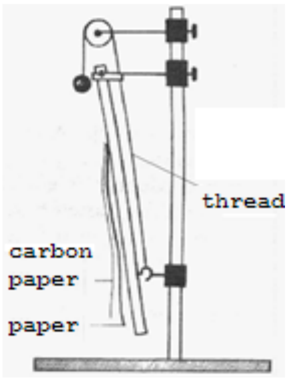
Physics experiments to be used in class

Topic 3: Determining gravitational acceleration with the help of "Audacity" (a multi-track audio editor and recorder)– Student Worksheet

MATERIALS

the baton and the pendulum (Chester Earl Whiting), stopwatch, tape-measure, computer with a microphone, and Audacity installed,	rough surface, a ball, a height-adjustable horizontal surface

1. INTRODUCTRY MEASURING: GRAVITATIONAL ACCELEATION (G) WITH THE BATON AND THE PENDULUM



Generally, when trying to measure gravitational acceleration, the difficulty we come across is that the falling object is so fast that we are not able to measure the time interval of the fall with necessary precision. To solve this problem, a pendulum, for example, could be used. Though in case we are talking about free fall as a phenomenon, the most exact measures should be taken. We could see the same problem come up during measurements with horizontally launched objects, using the vertical velocity component's time-distance formula to determine the horizontal velocity component. Altogether, the best solution for measuring gravitational acceleration is to use the baton and the pendulum (a machine constructed by Chester Earl Whiting), where we measure the time and the distance of the free-falling object by launching a wooden board at the same time we launch the object (this is what makes it a pendulum). We attach carbon paper to the wooden board on which the falling object can leave a mark. If you start the pendulum from its terminal position it should meet with the free-falling object in a quarter period, so the time of free fall can be calculated from the time of oscillation of the pendulum.

a) Using the construction on the picture, burn the thread, which will then launch the ball and the pendulum. Measure the distance of the free fall.

h =

b) Measure the oscillation of the wooden board. For this, record the time of ten swings.

T = the time of the free fall ***t =***

c) Using the time-distance formula of free fall, determine the gravitational acceleration.

$$h = \frac{g}{2} t^2$$

$$g = \frac{2h}{t^2} = 10.07 m/s^2$$

Student's copy

2. MEASUREMENT: DETERMINING GRATITATIONAL ACCELERATION WITH "AUDACITY"

Nowadays, there are several ways to measure the time of free fall with measuring instruments. We can use different creative solutions such as: digital clock with magnetic triggering or light gates as well. In this experiment, we will examine sections of the movement of a ball that was launched on a rough surface table, where we evaluate of sound effects recorded during this experiment.

The use of software is simple. Start the recording, then enlarge examined section of the sound sample to see the amplitude well. The time can be read on the horizontal axis and the software will display the length of the interval.

Follow the steps to perform the experiment:

Record the sound that the movement of the ball creates with "Audacity".

- Measure the time on the graph (it is the silent section between the sound of the rolling ball and sound of the impact) in millisecond.

- Repeat the measurement 4 times, as you launch the ball from different heights.

- Record your data into a table, where you include the height of the starting position of the ball, time, then create a graph using the height and the square of the time. Use the graph to determine the gravitational acceleration.

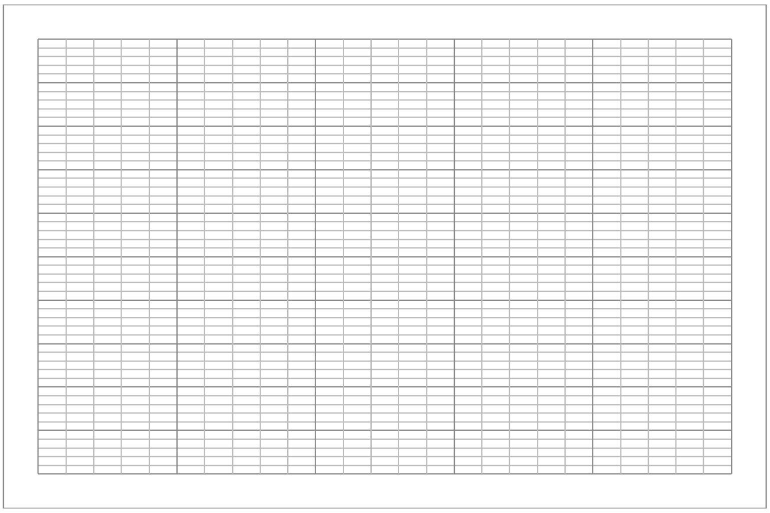
h (m)				
t (s)				
t^2 (s^2)				

Why it is worth plotting the square of the time on the horizontal axis?

....

Which data provides the value of 'g' in the calculated function?

....



Student's copy

Determine the absolute and relative deviation of the calculated results. To do this, calculate the value of 'g' to all the heights, calculate the average then calculate the average of the deviation from the average.

	1.	2.	3.	4.	$\bar{g}, \overline{\Delta g}$
$g\ (m/s^2)$					
$\Delta g = \lvert g_i - \bar{g} \rvert$					

$$\Delta g_{absz} = \overline{\Delta g} = \frac{\sum_{i=1}^{n} \lvert g_i - \bar{g} \rvert}{n} = 0{,}57 m/s^2$$

$$g = \bar{g} \pm \overline{\Delta g} = (9{,}12 \pm 0{,}57) m/s^2$$

$$g = \bar{g} \pm \frac{\overline{\Delta g}}{\bar{g}} = 9{,}12 m/s^2 \pm 6{,}25\%$$

There is a difference between g value based on the graph and the average g value calculated from the measurements. What is the reason for the difference, moreover, what is the graphical meaning of the average value?

....

Calculate all the evaluations with help of a computer program. Upload all the data to MS Excel (h-t2), then plot a linear graph.

Determine the equitation of graph given by MS Excel:

From this:

Check how MS Excel uses trend lines and fits them on the measurement points.

....

What kind of data is calculated by MS Excel to describe the error of the measurement?

....

Give the difference of 'g' between the used method and the given value in documentation.

Student's copy

Topic 3: Determining gravitational acceleration with the help of "Audacity" (a multi-track audio editor and recorder)– Teacher Worksheet

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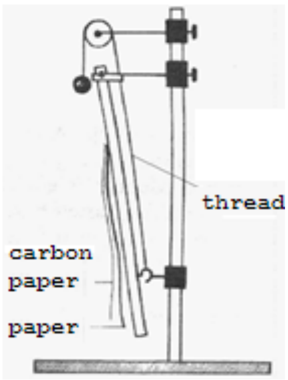

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d) Using the construction on the picture, burn the thread, which will then launch the ball and the pendulum. Measure the distance of the free fall.

h = 45.3 cm

e) Measure the oscillation of the wooden board. For this, record the time of ten swings.

T = 1.2 s the time of the free fall ***t = T/4=0.3 s***

f) Using the time-distance formula of free fall, determine the gravitational acceleration.

$$h = \frac{g}{2}t^2$$

$$g = \frac{2h}{t^2} = 10.07 m/s^2$$

Teacher's copy

2. MEASUREMENT: DETERMINING GRATITATIONAL ACCELERATION WITH "AUDACITY"

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The use of software is simple. Start the recording, then enlarge examined section of the sound sample to see the amplitude well. The time can be read on the horizontal axis and the software will display the length of the interval.

Follow the steps to perform the experiment:

Record the sound that the movement of the ball creates with "Audacity".

- Measure the time on the graph (it is the silent section between the sound of the rolling ball and sound of the impact) in millisecond.

- Repeat the measurement 4 times, as you launch the ball from different heights.

- Record your data into a table, where you include the height of the starting position of the ball, time, then create a graph using the height and the square of the time. Use the graph to determine the gravitational acceleration.

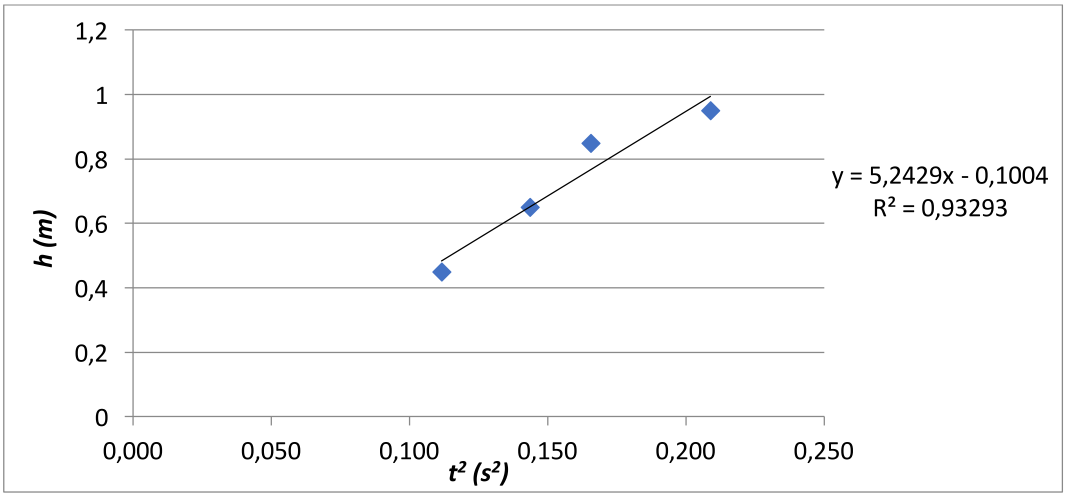
h (m)	**0.45**	**0.65**	**0.85**	**0.95**
t (s)	**0.334**	**0.379**	**0.407**	**0.457**
t^2 (s^2)	**0.112**	**0.144**	**0.166**	**0.209**

Why it is worth plotting the square of the time on the horizontal axis?

This way, it is easier to plot the function, even by hand.

Which data provides the value of 'g' in the calculated function?

Twice the steepness of the function.



Teacher's copy

Determine the absolute and relative deviation of the calculated results. To do this, calculate the value of 'g' to all the heights, calculate the average then calculate the average of the deviation from the average.

	1.	2.	3.	4.	$\bar{g}, \overline{\Delta g}$
g (m/s^2)	**8.07**	**9.05**	**10.26**	**9.10**	**9.12**
$\Delta g = \lvert g_i - \bar{g} \rvert$	**1.05**	**0.07**	**1.14**	**0.02**	**0.57**

$$\Delta g_{absz} = \overline{\Delta g} = \frac{\sum_{i=1}^{n} |g_i - \bar{g}|}{n} = 0{,}57 m/s^2$$

$$g = \bar{g} \pm \overline{\Delta g} = (9{,}12 \pm 0{,}57) m/s^2$$

$$g = \bar{g} \pm \frac{\overline{\Delta g}}{\bar{g}} = 9{,}12 m/s^2 \pm 6{,}25\%$$

There is a difference between g value based on the graph and the average g value calculated from the measurements. What is the reason for the difference, moreover, what is the graphical meaning of the average value?

The reason for the difference is that our method is based on connecting the crossing point of the axes with the measured values, and then averaging the steepness of these graphs.

Calculate all the evaluations with help of a computer program. Upload all the data to MS Excel (h-t2), then plot a linear graph.

Determine the equitation of graph given by MS Excel:

y = 5.2429x – 0.1004

From this: **g = 10.48m/s²**

Check how MS Excel uses trend lines and fits them on the measurement points.

It uses the method of taking the smallest squared values to obtain the value of 'g'.

What kind of data is calculated by MS Excel to describe the error of the measurement?

R^2 , which describes the error in how the trend line was fitted on the measured points.

Give the difference of 'g' between the used method and the given value in documentation.

$$\frac{|g_{ir} - g|}{g_{ir}} = \frac{|(9.81 - 10.48)| m/s^2}{9.81 m/s^2} \approx 0.07 \rightarrow 7\%$$

Notes:

The error in the measurement basically depends on the quality of the soundtrack recorded by Audacity. Accuracy can be increased by launching the ball on a rough ceramic tile, as stated in the description of the measurement. Furthermore, it also advisable to use a microphone with high sensitivity. The way this program works should definitely be shown to the students, letting them know how to enlarge signals with smaller amplitudes, and how to analyse a soundtrack recorded by the program. The time of the free fall can be marked on the sound sample, and the program will determine the length of this time interval.

http://www.audacityteam.org/download/

Teacher's copy

Topic 4: Fruit Battery – Student Worksheet

Accident Prevention, Rules

Use the tools properly.

Good to Know

Alessandro Volta 1745-1827
Italian physicist who elaborated the theory of the electric current, discovered the electrolysis of water and invented the Volta-battery (galvanic cell).

Necessary Material

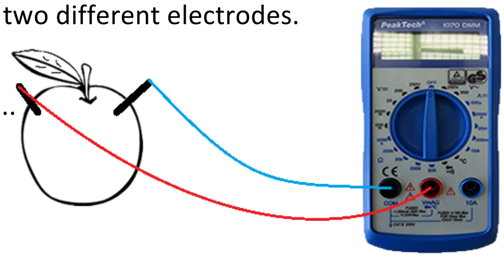
- ✓ 2 apples
- ✓ 2 different electrodes (copper, zinc)
- ✓ 1 wire with crocodile-clips on both ends

Necessary Tools

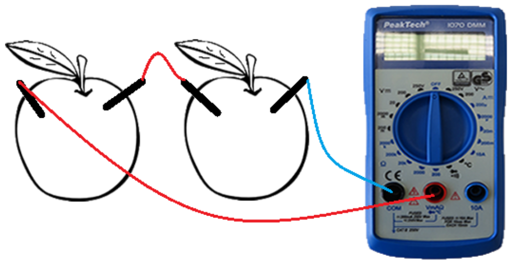
- ✓ electric meter
- ✓ 2 wires with crocodile-clips
- ✓ beaker with 50 ml acid water (vinegar)

Experiment 1

1. Construct a battery according to the example, use two different electrodes.
2. **Turn the measuring instrument to voltmeter!**
3. How much voltage does the instrument measure? ..
4. Turn off the instrument.



5. Connect another apple to the electric circuit as the figure indicates. Make sure that you connect the zinc and copper plates between the apples.
6. Turn on the instrument.
7. Read the measured

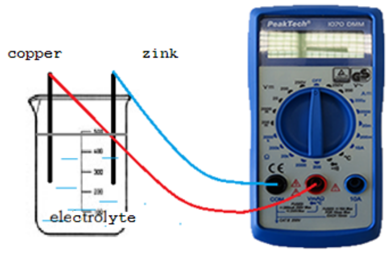


value. ....
(Even a clock can be operated with such a battery at home.)
8. Compare the two measured voltage values and explain the difference.
....
....

Student’s copy

EXPERIMENT 2

1. Submerge the pair of electrodes used in the previous experiments to a beaker that contains thin acid. **Be careful not to drop the liquid to your hands!**
2. Measure the voltage and note it down. ....
3. Lift out the electrodes, place them on the tray and turn the instrument. off
4. What do we call a galvanic cell?



....

....

EXERCISES, QUESTIONS

1. How many apples should you use to operate a 12V desk lamp? Use the data of the previous experiment.

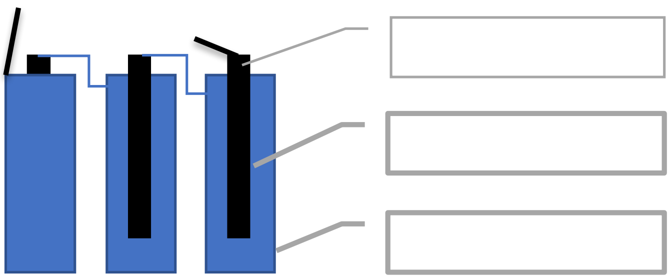
....

....

2. How would you connect the apples if you wanted to double the usage time of the apple-battery with the same load?

Drawing

3. Fill in the boxes with the appropriate parts of the apple-battery: zinc plate, copper plate, apple.



SHORTLY SUMMARISE WHAT YOU HAVE LEARNED FROM THE EXPERIMENT

....

....

Student’s copy

Topic 4: Fruit Battery – Teacher Worksheet

Accident Prevention, Rules

Use the tools according to instructions.

Background Information for the Teacher

The galvanic cell is an appliance in which ion formation and in isolation ion neutralization takes place.

- It can be used as a durable energy source
- In the galvanic cell an electric field builds up at the expense of chemical energy

The galvanic cells (commonly known as accumulator; or simply battery) are present in our everyday life, take for example mobile phones. But of course there are galvanic cells in computers, torches and alarm clocks as well. A galvanic cell can be built at home too. The easiest way is to stick a zinc and a copper bar in a lemon. If we connect a load to the metal sticks, our little electric circuit will be ready. Of course a fridge will not run with the help of a lemon, nor a mobile phone, but a small light bulb might work. Metal ions get from the metal stick that contacts the electrolyte into the solution and the metal ions in the solution precipitate to the surface of the metal as neutral atoms.

In the Daniel-battery isolated redox reaction takes place, on the zinc electrode oxidation, on the copper electrode reduction.

$Zn = Zn^{2+} + 2e-$ (oxidation) $Cu^{2+} + 2e- = Cu$ (reduction)

The zinc electrode is the anode of the Daniel-battery and the copper electrode is the cathode. The electrons, accumulating on the zinc electrode, can get to the copper electrode only on an external conductor, thus generating the electric current. The zinc electrode operates as the battery's negative, the copper electrode as its positive pole. We use galvanic cells in numerous fields of everyday life. The simplest representatives of these are the AA battery and the different button cells. By the serial connection of more cells batteries can be created. The flat pocket battery is an example.

Recommended website: http://hetikiserlet.blog.hu/2014/11/21/gyumolcselem

The Necessary Prior Knowledge

It is essential that the students know the concepts of voltage and amperage, are be able to create a simple electric circuit, based on a drawing and explanation. They are able to use the voltmeter and ampere meter properly. They need to know the simple, serial and parallel connection types. They are able to implement the electric circuit symbols. Knowledge of oxidation-reduction reactions.

Necessary Material

- ✓ 2 apples
- ✓ 2 different electrodes (copper, zinc)
- ✓ 1 wire with crocodile-clips on both ends

Necessary Tools

- ✓ electric meter
- ✓ 2 wires with crocodile-clips
- ✓ beaker with 50 ml acid water (vinegar)

Teacher's copy

EXPERIMENT 1

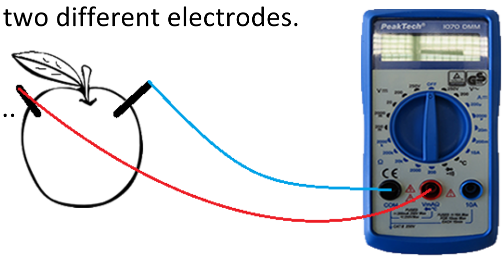
Before starting the experiment shortly explain how to use the voltmeter. Call the students' attention to the fact that they need to use the proper connection points of the instrument.

When turning on the instrument, turn the range selector switch to voltmeter.

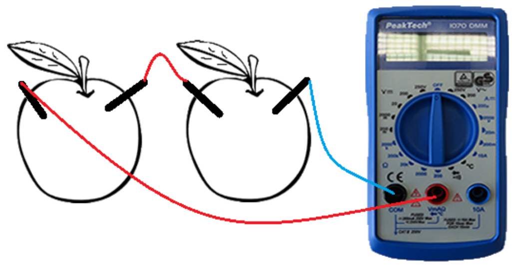
If the measured value is negative it means that the direction of the current is reverse, this does not influence the measured value, we need to drop the minus signs when noting down the data.

Remind the students that the kinds and pairing of the metal sticks used as electrodes influence the voltage of the battery.

9. Construct a battery according to the example, use two different electrodes.
10. **Turn the measuring instrument to voltmeter!**
11. How much voltage does the instrument measure? ..
12. Turn off the instrument.



13. Connect another apple to the electric circuit as the figure indicates. Make sure that you connect the zinc and copper plates between the apples.
14. Turn on the instrument.
15. Read the measured



value. ....

(Even a clock can be operated with such a battery at home.)

16. Compare the two measured voltage values and explain the difference.

....

....

In the second experiment the two apples are connected in series. So the measured voltage is the sum of the values of voltage measured on the apples separately.

$U = U1+U2$; 1.4 V = 0.7 V +0.7V

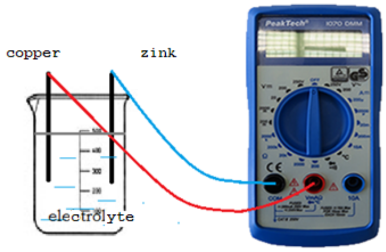
EXPERIMENT 2

Reminder for the students

Store the discharged batteries in a closed container due to the acids and heavy metals, dispose them at a recycling depot or at a nearby collection point.

We can also call the students' attention to the fact that being economical with the energy and the use of renewable energy helps to protect the nature and our own environment.

Teacher's copy



5. Submerge the pair of electrodes used in the previous experiments to a beaker that contains thin acid. **Be careful not to drop the liquid to your hands!**
6. Measure the voltage and note it down.............
7. Lift out the electrodes, place them on the tray and turn off the instrument.
8. What do we call a galvanic cell?

   ....

   ....

The electrochemical cells that derive energy form redox reaction are called galvanic cells.

The galvanic cell consists of two electrodes (half a cell). The simplest galvanic cell is when two clear metal electrodes sink into a slat solution, containing their own ions. In the salt solution there are the oxidized, positive charged cations of the electrode metal and the anions neutralizing them. The electrodes contain the metal in two different oxidation states.

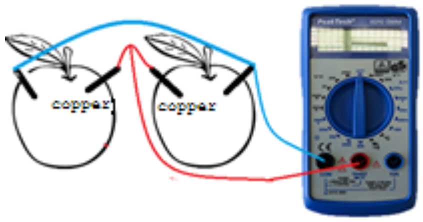
It was named after Luigi Galvani Italian doctor, physicist.

EXERCISES, QUESTIONS

4. How many apples should you use to operate a 12V desk lamp?
   12V/0.7V= 17.14

   So we need to connect at least 18 apples in series to reach that the 0.7V voltage values added up.
5. How would you connect the apples if you wanted to double the usage time of the apple-battery with the same load?

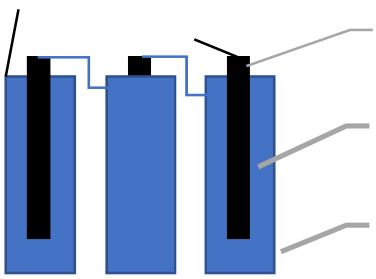
Drawing



We connect the apples in parallel so the capacity of the battery doubles. It can provide the same current for twice as long.

6. Fill in the boxes with the appropriate parts of the apple-battery: zinc plate, copper plate, apple.

Write the parts of the apple-battery to the suitable place: zinc plate, copper plate, apple.



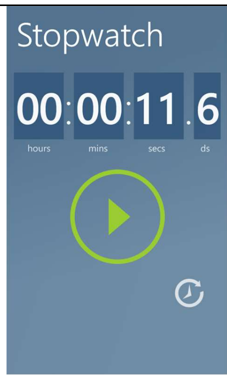
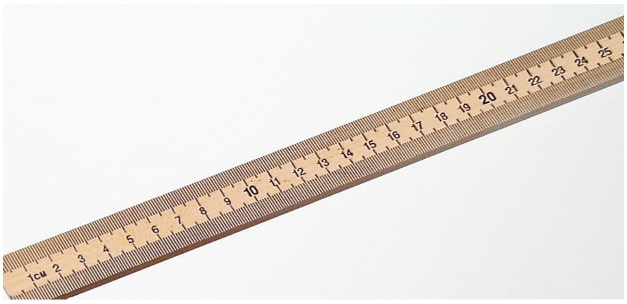
zinc plate

apple

copper plate

Teacher’s copy

Topic 5: Determining the acceleration due to gravity with a simple pendulum: g – Student Worksheet

Experiment materials	
1. Iron Bar. **2. Iron stand** **3. bar with hook** **4. mass - bob** **5. non extensible wire** **6. stopwatch** **7. meter stick** **8. caliper** **9 calculator,** **10 paper and pencil**	       

Student's copy

1. Install the material as in figure 1

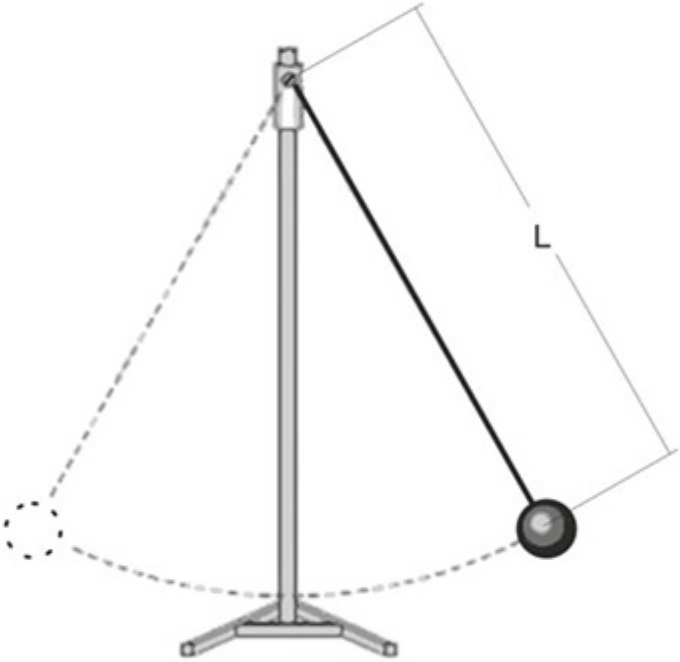


figure 1

2. Measurements

Fill in the following table:

Data:

Given: $g_{accepted} = 9.81\ m/s^2$.

Measured:

Trial	Length (L) [meters]	Total time of oscillations (t) [seconds]	Number of Oscill. (N)	T = t /N [seconds]	g = 4π² L /T2
1					
2					
3					
4					
				Mean "g" :	

Student’s copy

3. The experiment

The experiment consists in the **t**ime measurements of 20 oscillations, using an angle of about 10 degrees.

4. Calculation(s):

Calculate the time of one oscillation or the period (T) by dividing the total time by the number of oscillations you counted.

Repeat the above procedure for 10 more cases and work out the average.

5. Conclusion:

State your conclusions of the experiment.

Experiment Result

The result for **g** obtained from both measured values of L and T^2 from equation $T^2 = 4\pi^2 L/g$

QUESTIONS

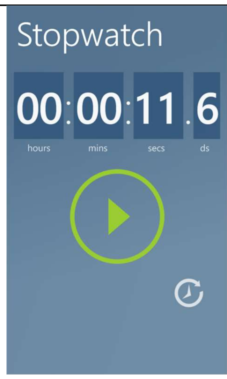
1. From your data what effect does changing the mass have on the period (for a given value of the length L)?
2. What role, if any, does air resistance have on your results? Explain your reasoning.
3. Would you conclude that Galileo was correct in his observation that the period of a simple pendulum depends only on the length of the pendulum?
4. On the moon, the acceleration due to gravity is one-sixth that of earth. That is $g_{moon} = g_{earth}/6 = (9.8\ m/s2)/6 = 1.63\ m/s2$. What effect, if any, would this have on the period of a pendulum of length L? How would the period of this pendulum differ from an equivalent one on earth?
5. What is your evidence for believing or disbelieving that your reaction time is always the same? Is your reaction time different for different stimuli?
6. Suggest possible explanations why reaction times are different for different people.
7. Will the reaction time significantly affect measurements you might make using instruments for this course? How could you minimize its role?
8. What role does reaction time play in applying the brakes to a car in an emergency situation? Estimate the distance a car travels at 100 km/h during your reaction time in braking.

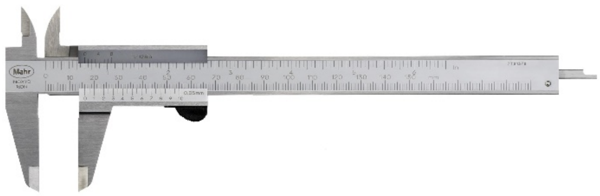
Student’s copy

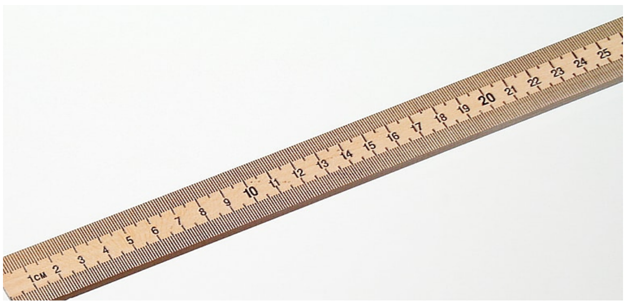
Topic 5: Determining the acceleration due to gravity with a simple pendulum: g – Teacher Worksheet

Experiment materials

1. Iron Bar.
2. Iron stand
3. bar with hook
4. mass - bob
5. not extensible wire
6. stopwatch
7. meter stick
8. caliper
9 calculator,
10 paper and pencil







Teacher’s copy

Experimental Procedure:

1. Installation of the material as in figure 1

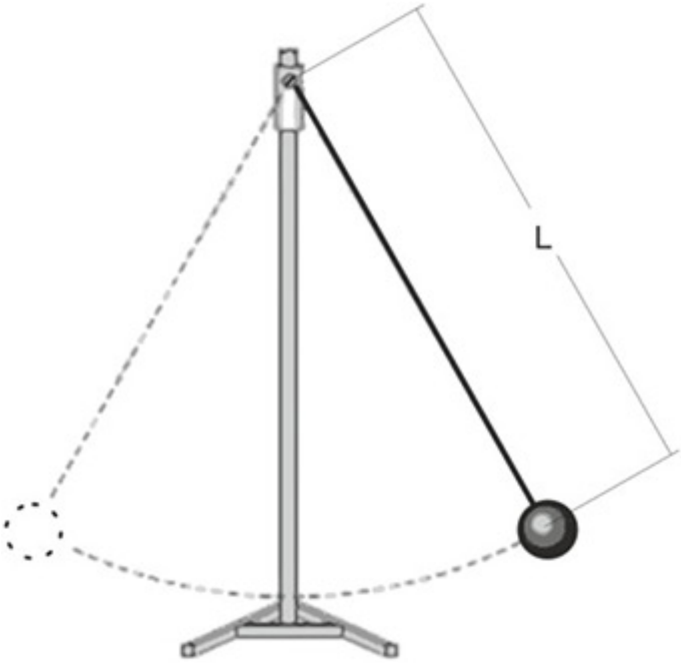


figure 1

2. Measurements

As shown in Figure 1, the pendulum apparatus was set up using a round metal bob with a hook attached to a string. The string was passed through a hole in an iron bar, which was supported by a tripod. The length of the string could be adjusted, and the precise point of oscillation was fixed by a screw, which was also connected to a protractor and to the iron bar.
Length measurements for the pendulum were taken using a meter stick and caliper. The caliper was used to measure the diameter of the bob, having an uncertainty of 0.01cm. The total length was measured by holding the meter stick up against the iron bar, and measuring from the pivot point to the bottom of the bob. The bottom was determined by holding a ruler horizontally against the bottom of the bob. The meter stick measurements had an uncertainty of 0.2cm.

3. The experiment

The experiment consists in the time measurements of 20 oscillations, using an angle of about 10 degrees.

In this way the small angle approximation introduces a small systematic error in the period of oscillation, T.
By measuring 20 oscillations the average period is determined by dividing by 20 and this helps reduce the error since the error propagation will provide an uncertainty in the period that is the uncertainty in the time measurement divided by 20. Measurements taken at less than 10 degrees will be more accurate for the small angle approximation model that was used.

Teacher's copy

Time measurements were made using a stopwatch. To measure the first swing the starting time was determined by holding the bob in one hand and the stopwatch in the other and simultaneously releasing the bob and pushing Start. The stopping point, and starting point for the second oscillation, was determined by watching the bob and pushing Stop/Start when the bob appeared to reach the top of the twentieth swing and stop. The precision of the stopwatch was compared with another measurement done by a different person. The precision of the time measurements were also affected by reaction time and perception of starting and stopping points of the person taking the measurements. Time measurements were taken by the same person to keep the uncertainty in reaction time consistent.

4. Calculation(s):

Calculate the time of one oscillation or the period (T) by dividing the total time by the number of oscillations you counted.

Repeat the above procedure for 10 more cases and make the average.

5. Conclusion:

State your conclusions of the experiment.

Theory:

Gravity exerts a force on every object. This force is proportional to the mass of the object. The proportionality constant is the acceleration of gravity "g." The gravity acceleration (g) decreases with increasing elevation; however, for a few thousand feet above the Earth's surface, it remains fairly constant. In this experiment, a simple pendulum will be used to measure "g ." A simple pendulum is made of a long string and a tiny metal sphere, steel or preferably lead (higher density). The period of oscillation of a simple pendulum may be found by the formula

$$T = 2\pi \sqrt{\frac{L}{g}}$$

from which we may calculate "g" as

$$g = \frac{4\pi^2 L}{T^2}$$

Teacher's copy

As the first formula shows, the stronger the gravitational pull (the more massive a planet), the greater the value of g , and therefore, the shorter the period of oscillations of a pendulum swinging on that planet. If the pendulum has a steel ball, and a magnet is placed underneath the arc where it travels back and forth as it swings, the pace of oscillation does change and it swings faster. Swinging faster results in a shorter period T. Symbol g is in the denominator. A greater g means a smaller T

The filling in of the following table is required of the students:

Data:

Given: $g_{accepted} = 9.81\ m/s^2$.

Measured:

Trial	Length (L) [meters]	Total time of oscillations (t) [seconds]	Number of Oscill. (N)	$T = t/N$ [seconds]	$g = 4\pi^2 L / T^2$
1					
2					
3					
4					
				Mean "g" :	

Teacher's copy

The result for **g** obtained from both measured values of L and T^2 from equation $T^2 = 4\pi^2 L/g$ as well as from the slope in the Linear Fit model agree very well with accepted results for g. The precision could be improved by corrections for effects of mass distribution, air buoyancy and damping, and string stretching.

By measuring 20 oscillations the average period is determined by dividing by 20 and this helps reduce the error since the error propagation will provide an uncertainty in the period that is the uncertainty in the time measurement divided by **20.** Measurements taken at less than 10 degrees will be more accurate for the small angle approximation model that was used.

Two methods were used to calculate a value of g from the data.

The first method used to calculate a value of g from the measurements taken is making the calculation from each of the ten different lengths, using the measurements of 20 oscillations at the different lengths, and taking the average. The calculated average **g** was **(9.7 + / − 0.1) m/s²** .

The second method used was applying a linear least squares fit to the values of length and the accompanying T^2 .
The value of g is determined by using the slope of the line which gave a value of **g to be (9.8 + / − 0.1) m/s²** .

The experiment was a good way of testing the small angle approximation.

Using the small angle approximation the relationship between period squared and length was linear so a least squares linear fit could be used to calculate g.

This experiment tested a mathematical model for the value of gravity that makes use of the small-angle approximation and the proportional relationship between the square of the period of oscillations to the length of the pendulum. Sources of error for this procedure included precision in both length and time measurement tools, reaction time of the stopwatch holder, and the accuracy of the stopwatch. The final result of g takes into account the correction for the error introduced using the approximation. There are opportunities to correct for the effects of mass distribution, air buoyancy and damping, and string stretching.

The simple pendulum provides a way to repeatedly measure the value of g. The equation of motion from the free body.
$F = ma$
can be written in differential form and offers the value of T in this form.

$T^2 = 4\pi^2 L/g$
Using the small angle approximation introduces a small systematic error in the period of oscillation, T.
This experiment used an angle of about 10 degrees.

Teacher's copy

	Time measurements were made using a stopwatch. To measure the first swing the starting time was determined by holding the bob in one hand and the stopwatch in the other and simultaneously releasing the bob and pushing Start. The stopping point, and starting point for the second oscillation, was determined by watching the bob and pushing Stop/Start when the bob appeared to reach the top of the twentieth swing and stop. The precision of the stopwatch was compared with another measurement done by a different person. The precision of the time measurements were also affected by reaction time and perception of starting and stopping points of the person taking the measurements. Time measurements were taken by the same person to keep the uncertainty in reaction time consistent.
QUESTIONS	1. From your data what effect does changing the mass have on the period (for a given value of the length L)? 2. What role, if any, does air resistance have on your results? Explain your reasoning. 3. Would you conclude that Galileo was correct in his observation that the period of a simple pendulum depends only on the length of the pendulum? **4.** On the moon, the acceleration due to gravity is one-sixth that of earth. That is $g_{moon} = g_{earth} /6 = (9.8\ m/s2\ )/6 = 1.63\ m/s2$. What effect, if any, would this have on the period of a pendulum of length L? How would the period of this pendulum differ from an equivalent one on earth?
	5. What is your evidence for believing or disbelieving that your reaction time is always the same? Is your reaction time different for different stimuli? 6. Suggest possible explanations why reaction times are different for different people. 7. Will the reaction time significantly affect measurements you might make using instruments for this course? How could you minimize its role? 8. What role does reaction time play in applying the brakes to a car in an emergency situation? Estimate the distance a car travels at 100 km/h during your reaction time in braking.

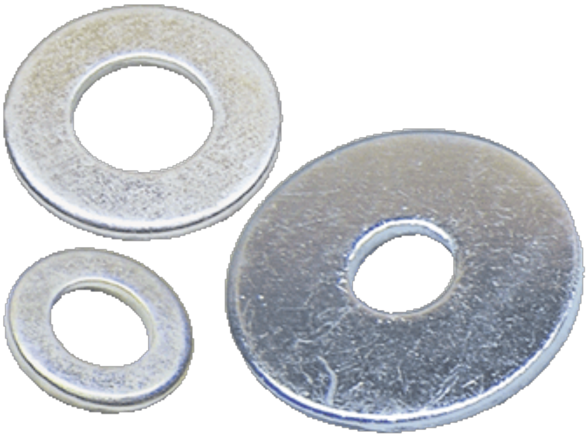
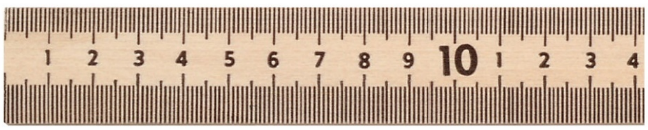
Teacher's copy

Topic 6: Newton's second law of motion – Student Worksheet

Objectives	Students will • Understand how motion or distance travelled depends on mass and force. • Investigate the relationship between force, mass, and acceleration as described by Newton's 2nd Law of Motion.
Motivation for Learning	**Driving Question** In this experiment, the force will be applied by rolling balls of different masses down a ramp. A wooden, glass, and metal ball will be used to vary the force used. A small box (or paper cup) with a hole cut in one side will be used to measure the acceleration by measuring how far the box travels. The box will be placed at the bottom of the ramp to catch the balls. A second part of this experiment will use a constant force (metal ball), and the mass of the object at rest (the box) will be varied by adding washers to the top of the box. The greater the mass of the ball rolling down the ramp, the farther the box should travel. When more mass (washers) is taped to the box, the box should move less.
Experiment materials • Ramp (1 meter long), cove moulding or meter sticks can be used, with side rails on each side to keep the balls on the ramp;	

Student's copy

• 3 balls, wooden, glass, and metal (12 mm or ½ inch works well);	  
A small cardboard box (7 x 6 x 4 cm), or a paper cup (cut a 3 x 3 cm hole in one side of the cup at the very top); **Student's copy**	

• 3 medium size washers	
• 4 textbooks	
• Meter stick • Tape	  
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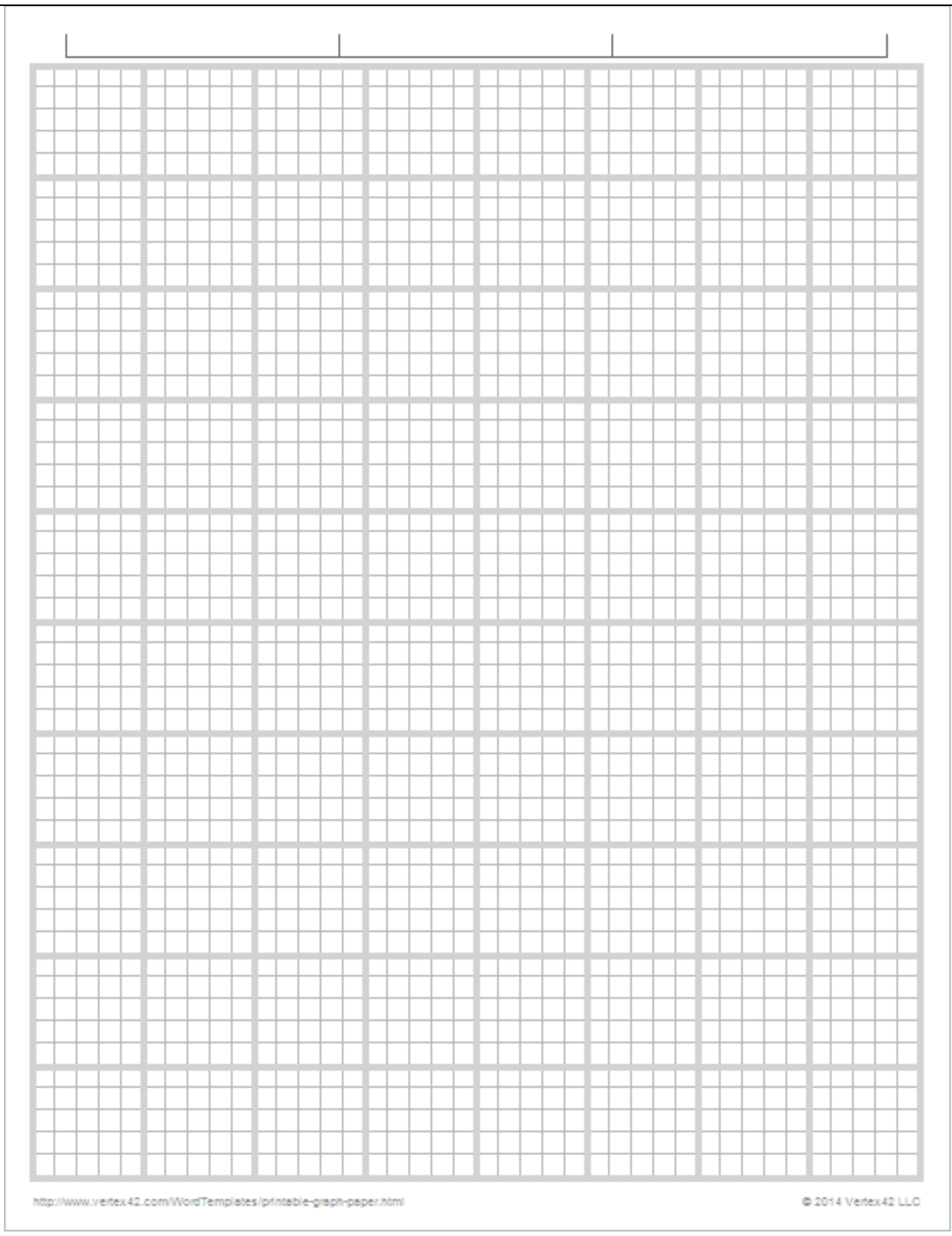
• Graph paper	

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Background Information

This experiment is designed to verify Newton's 2nd Law of Motion. Force equals mass multiplied by acceleration. This law states that a force on an object will cause it to accelerate in the direction of the force. The greater the force exerted on the object, the greater the acceleration. For any given force, the greater the mass of an object, the smaller the acceleration.

Procedure

Part 1:

1. After reading the procedure, answer the 1st question before starting the experiment.
2. Make an inclined plane using the cove molding and four textbooks.
3. Place the box or cup upside down on the table at the bottom of the ramp with the opening facing the ramp, so it will catch a ball as it is rolled down the ramp.
4. Roll the wooden ball down the ramp and measure how far the box or cup moved from its starting position.
5. Record your data and repeat twice.
6. Roll the glass ball down the ramp and measure how far the box or cup moved from its starting position.
7. Record your data and repeat twice.
8. Roll the metal ball down the ramp and measure how far the box or cup moved from its starting position.
9. Plot your results, with the type of ball on the x-axis, and the distance the box or cup moved on the y-axis.

Part 2:

10. Tape 1 washer on top of the box or cup.
11. Roll the metal ball down the same ramp and measure how far the box or cup moved from its starting position.
12. Record your data and repeat twice.
13. Repeat with two washers, then with three washers.
14. Record your data and repeat twice.
15. Plot your results, with the number of washer on the x-axis, and the distance the box or cup moved on the y-axis.

Student's copy

Data Table

Distance Travelled by the box or cup (cm)

	Trial 1	Trial 2	Trial 3	Average
Wooden Ball				
Glass Ball				
Metal Ball				
1 Washer				
2 Washers				
3 Washers				

QUESTIONS

Force, Acceleration and Newton's Second Law of Motion

Student's copy

1. Write a hypothesis for both parts of this experiment.
2. How does the force of the moving object (type of ball) affect the distance travelled by the cup?
3. How does the mass of the object at rest (box or cup) affect how far it travels when hit by the metal ball?
4. Describe the relationship between force (mass of ball) and the distance the box or cup moved. Describe the

relationship between the mass of the box or cup, and the distance the box or cup moved. Do you agree with Newton’s 2^{nd} Law of Motion?

5. Did your results support your hypothesis? Explain.

Which of the following statements are true of the concept of **force**? List all that apply.

a. A force is a push or pull exerted upon an object which results from the interaction of that object with its environment.
b. Bubba approaches Billie and gives him a swift shove. Timid little Billie keeps his hands in his pocket during this interaction. Subsequently, while Bubba places a force upon Billie, Billie does not place a force upon Bubba.
c. A quarterback throws a football down field. Once thrown, the force from the quarterback persists upon the ball to cause it to continue on its upward trajectory towards its peak.

A sled slides down the hill and reaches the bottom where it

Student’s copy

	d. gradually slows to a stop. Once on the level ground, the force of the hill persists upon the sled to allow it to continue its forward motion. e. Forces always cause objects to move. f. An object can experience two or more forces and not accelerate. g. A contact force results from the physical contact between two objects. h. A field force results from the action of two objects which are positioned some distance away. i. Spring and tension forces are examples of field forces. j. A force is a vector quantity; there is always a direction associated with it. k. Force can be measured in kilograms or Newtons depending upon the system of measurement (metric or otherwise).

Student's copy

Topic 6: Newton's second law of motion – Teacher Worksheet

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Motivation for Learning	**Driving Question** In this experiment, the force will be applied by rolling balls of different masses down a ramp. A wooden, glass, and metal ball will be used to vary the force used. A small box (or paper cup) with a hole cut in one side will be used to measure the acceleration by measuring how far the box travels. The box will be placed at the bottom of the ramp to catch the balls. A second part of this experiment will use a constant force (metal ball), and the mass of the object at rest (the box) will be varied by adding washers to the top of the box. The greater the mass of the ball rolling down the ramp, the farther the box should travel. When more mass (washers) is taped to the box, the box should move less.
Experiment materials • Ramp (1 meter long), cove moulding or meter sticks can be used, with side rails on each side to keep the balls on the ramp; • 3 balls, wooden, glass, and metal (12 mm or ½ inch works well);	  

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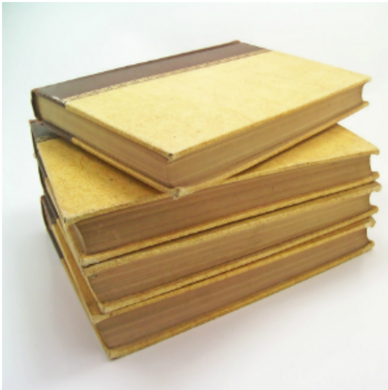
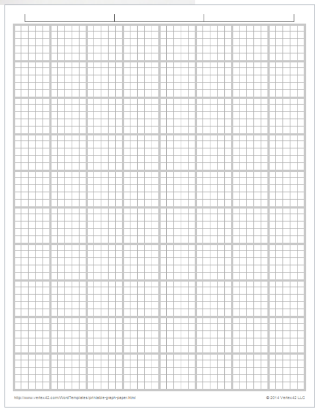
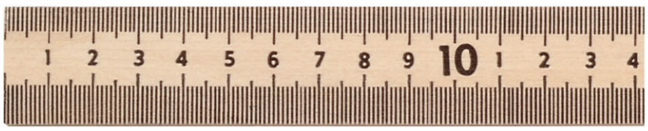
- A small cardboard box (7 x 6 x 4 cm), or a paper cup (cut a 3 x 3 cm hole in one side of the cup at the very top);
- 3 medium size washers
- Meter stick
- 4 textbooks
- Tape
- Graph paper







Background Information

This experiment is designed to verify Newton's 2nd Law of Motion. Force equals mass multiplied by acceleration. This law states that a force on an object will cause it to accelerate in the direction of the force. The greater the force exerted on the object, the greater the acceleration. For any given force, the greater the mass of an object, the smaller the acceleration.

Theory: The dynamics of mechanical systems was first stated by Isaac Newton in his *Principia* of 1687. Newton's laws form the basis for the derivation of the equations of motion for particles. Modern dynamics is introduced through the use of vectors, free-body diagrams and reference frames. The use of particle mass to represent a body is an idealized concept that provides the simplest model in dynamics. It is important to note that Newton's second law, in its present form, has been used to derive current dynamic principles such as work and energy. Dynamics is made easy by transforming its vectorial representation to scalar forms by means of using dot products. This was the basis for variational principles. We shall review the dot product and cross product of vectors to see how some of these rules apply. The aim of this experiment is to review the basic principles in Newton's second law to formulate the equation of motion of problems involving system of particles.

Newton's first law of motion states that an isolated object has no acceleration. His second law of motion gives the relationship between the acceleration of an object and the forces acting on it. The second law of motion is: The (vector) acceleration of an object is proportional to the (vector) force acting on it. As an equation this is: F ~ = m ~ a , (1) where m is the mass of the object. Thus, in the case of a single force applied to an object, if you know any two of the three quantities F ~ , m, or ~ a you can immediately solve the equation.

A number of simple experiments demonstrate that Newton's second law is consistent with both your intuitive notions and with nature. You know that if you push an object its velocity changes. By doing a simple experiment involving a block sliding on a more or less frictionless surface and using a spring scale, you can establish that the block accelerates in the direction of the force and that the acceleration is proportional to the force. You can easily devise a number of similar experiments involving pushes, pulls, and simple measuring devices. In all cases, you will find that the acceleration is proportional to the magnitude of the force as determined by the measuring device and that this magnitude corresponds roughly to your own physiological impression of "how hard" you have pushed or pulled the object. This is just what the second law says.

Teacher's copy

Procedure

Part 1:

1. After reading the procedure, answer the 1st question before starting the experiment.
2. Make an inclined plane using the cove moulding and four textbooks.
3. Place the box or cup upside down on the table at the bottom of the ramp with the opening facing the ramp, so it will catch a ball as it is rolled down the ramp.
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5. Record your data and repeat twice.
6. Roll the glass ball down the ramp and measure how far the box or cup moved from its starting position.
7. Record your data and repeat twice.
8. Roll the metal ball down the ramp and measure how far the box or cup moved from its starting position.
9. Plot your results, with the type of ball on the x-axis, and the distance the box or cup moved on the y-axis.

Part 2:

10. Tape 1 washer on top of the box or cup.
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13. Repeat with two washers, then with three washers.
14. Record your data and repeat twice.
15. Plot your results, with the number of washer on the x-axis, and the distance the box or cup moved on the y-axis.

Teacher's copy

The filling in of the following table is required of the students:

Data Table

Distance Travelled by the box or cup (cm)

	Trial 1	Trial 2	Trial 3	Average
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Glass Ball				
Metal Ball				
1 Washer				
2 Washers				
3 Washers				

QUESTIONS

- Write a hypothesis for both parts of this experiment.
- How does the force of the moving object (type of ball) affect the distance travelled by the cup?
- How does the mass of the object at rest (box or cup) affect how far it travels when hit by the metal ball?
- Describe the relationship between force (mass of ball) and the distance the box or cup moved. Describe the relationship between the mass of the box or cup, and the distance the box or cup moved. Do you agree with Newton's 2nd Law of Motion?
- Did your results support your hypothesis? Explain.

Which of the following statements are true of the concept of **force**? List all that apply.

l. A force is a push or pull exerted upon an object which results from the interaction of that object with its environment.
m. Bubba approaches Billie and gives him a swift shove. Timid little Billie keeps his hands in his pocket during this interaction. Subsequently, while Bubba places a force upon Billie, Billie does not place a force upon Bubba.
n. A quarterback throws a football down field. Once thrown, the force from the quarterback persists upon the ball to cause it to continue on its upward trajectory towards its peak.

Teacher's copy

Force, Acceleration and Newton's Second Law of Motion **Teacher's copy**	o. A sled slides down the hill and reaches the bottom where it gradually slows to a stop. Once on the level ground, the force of the hill persists upon the sled to allow it to continue its forward motion. p. Forces always cause objects to move. q. An object can experience two or more forces and not accelerate. r. A contact force results from the physical contact between two objects. s. A field force results from the action of two objects which are positioned some distance away. t. Spring and tension forces are examples of field forces. u. A force is a vector quantity; there is always a direction associated with it. v. Force can be measured in kilograms or Newtons depending upon the system of measurement (metric or otherwise). **Answer: AFGJ and sort of H.** a. **True** - This is a great definition of force. b. **False** - According to Newton's third law, one cannot push on an object without being pushed back. The force on Billie is the result of an interaction of Bubba's hands with Billie's body. That force on Billie might cause Billie to go flying, but the *reaction force* offers resistance to the motion of Bubba's hands and slows them down. In general, forces will always (without exception) come in pairs. c. **False** - The force of the quarterback on the football is a contact force which can only exist during the interaction (i.e., the contact) between the quarterback's hands and the football. Once thrown, the football continues its horizontal motion due to its own inertia and its vertical motion is effected by the force of gravity. d. **False** - Be careful if you answered true to this one. If you did, perhaps you believe in the fatal misconception that a rightward force is required to sustain a rightward motion. The sleds motion to the right can be described as a leftward accelerated motion. Such a leftward acceleration demands that there is a leftward force (despite its rightward force). This leftward force slows the rightward-moving sled down. The hill cannot *push* on the sled unless the hill is in contact with the sled. e. **False** - Forces, if unbalanced, can cause objects to accelerate (one form of moving; the other form is moving at a constant velocity). But by no means can one say that forces always cause objects to move. For instance, as you sit on your chair, the chair pushes up on your body but your body does not move. f. **True** - Certainly! As you sit in your chair, the chair pushes up on your body but your body does not accelerate. This upward force

	(known as the normal force) is balanced by the downward force of gravity. Many objects experience a force yet do not accelerate. g. **True** - There are two broad categories of forces - contact forces and field forces. Contact forces, by definition, are those which result from the physical contact of two forces. h. **True (mostly)** - A field force is a force which can acts between two objects even when they are separated by a distance. Field forces have magnitudes which are dependent upon the distance of separation between the two interacting objects. For instance, the force of gravity between the Sun and the earth is a field force whose value depends upon the distance of separation between the centre of the Earth and the centre of the Sun. In this sense, the force of gravity is a force which acts when two objects are separated in space from each other. Yet field forces can also occur when the two objects are touching each other. In this sense, one can be sceptical of the wording of the statement. i. **False** - Spring and tension are examples of contact forces. The spring or the rope/cable/wire are in contact with the object upon which it exerts its push or pull. The field forces are electric force, magnetic force, and gravity force. j. **True** - Forces always have a direction associated with them. As such, force is a vector quantity - a quantity which is fully described by both a magnitude (size, value) and a direction. k. **False** - Force is measured in Newtons in the metric system and in pounds in the British system. Kilograms is a unit of mass.

Teacher's copy

Topic 7: Resistance of LDR and NTC

Experiment:

The mode of operation of two unknown resistance is to be tested.

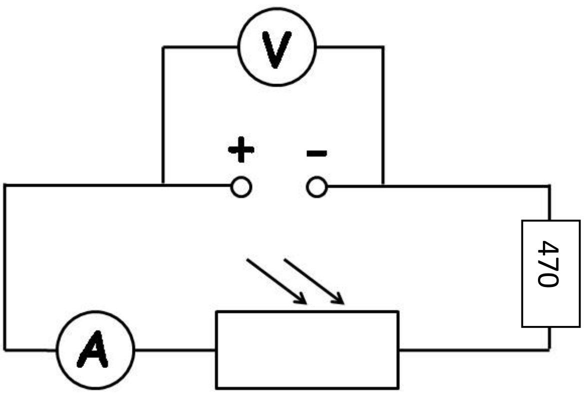


fig. 1: circuit LDR

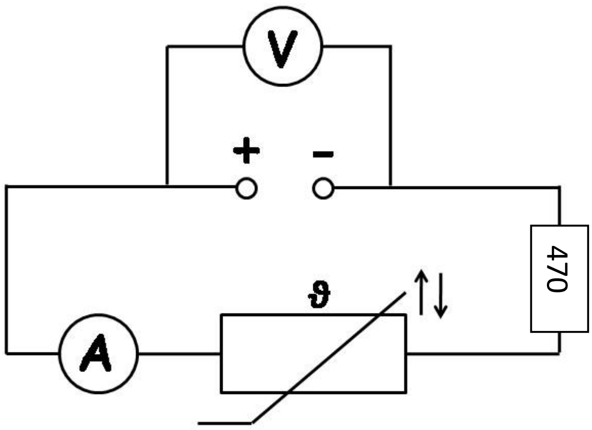


fig. 2: circuit NTC

Material:

- 1 electronic source
- 1 photoconductive cell (LDR)
- 1 thermal resistor (NTC)
- 1 candle
- 1 voltmeter
- 1 ampere meter
- cable
- torch
- 470Ω-resistance

Feedthrough:

Set up the circuit design (see fig.1 and fig.2). Use a **5V** voltage.

Circuit 1 with LDR:

Meter the conduction current with reference to the illumination of the resistance.
Take three different measurements and fill in the chart.

Illumination	I in mA
dark (covered by hand)	
medium (day light)	
bright	

Circuit 2 with NTC:

Meter the conduction current with reference to the temperature of the resistance.
(Note: You can warm the NTC with a flame.)
Take three different measurements and fill in the chart.

temperature	I in mA
room temperature	
candle (10 sec.)	
candle (20 sec.)	

Evaluation:

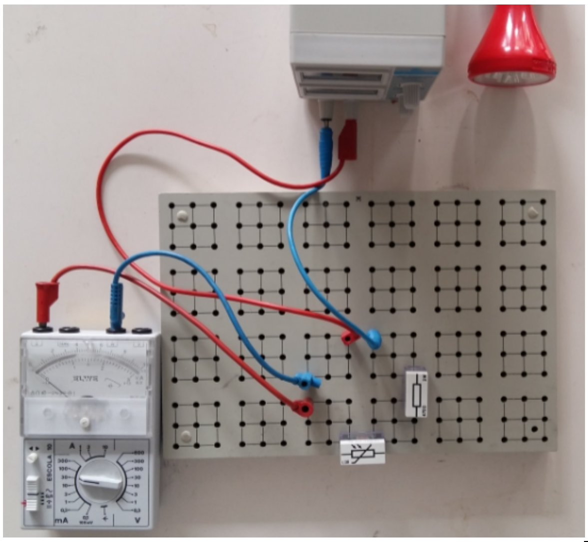
Describe your observations of both resistance.

Student's copy

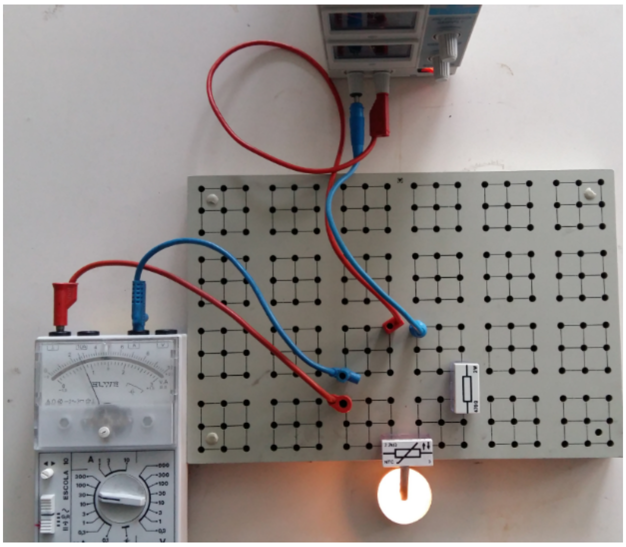
Solution

Experimental setup

LDR:



NTC:



Component LDR by Leybold:

Test reading

LDR:

NTC:

Illumination	I in mA
dark (covered by hand)	*4*
medium (day light)	*18*
bright (torch)	*24*

Temperature	I in mA
room temperature	*7*
candle (10 sec.)	*13*
candle (20 sec.)	*16*

Evaluation:

LDR: An increase of illumination leads to an increase of the conduction current → resistance decreases.

NTC: An increase of temperature leads to an increase of the conduction current → resistance decreases.

Topic 8a: Characterisitc curve of an LED (analogue data logging)

Experiment:

Today you get to know a new device – the light-emitting diode (abbr. **LED**).

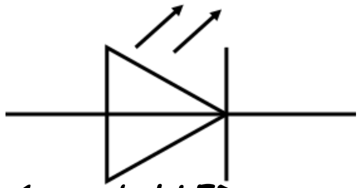


fig. 1: symbol LED

Material:

- 1 electronic source with a voltmeter
- 1 ampere meter (analogue)
- 3 LEDs (red, yellow, green)
- cable
- 470Ω-resistance

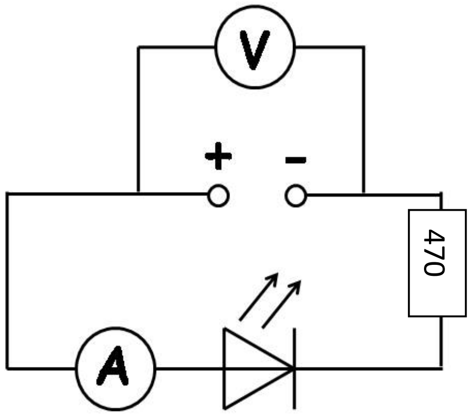


fig. 2: circuit LED

Feedthrough:

1. Construct the circuit according to fig. 2.
2. Watch out for the correct polarity of the LED. The label for cathode and anode is marked on the back of the LED.
3. Meter the conduction current with reference to the voltage of the LED. Apply a **maximum of 10V** and make sure that the conduction current of the LED is **not more than 45mA**.
   Note: If you exceed the given values, you'll ruin the LED!
4. Use the chart below to fill in your measured data.

Observartion:

	red	yellow	green
U in V	I in mA	I in mA	I in mA
0			
0,5			
1			
1,5			
2			
2,5			
3			
3,5			
4			
4,5			
5			
5,5			
6			

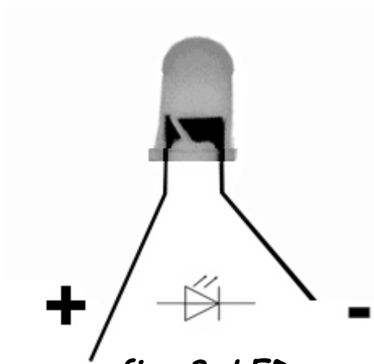


fig. 3: LED

Evaluation:

1. Describe your observations.
2. Transfer the measured data into a **collective** U-I-diagram. Choose your own suitable scale.

Student's copy

Topic 8b: Characteristic curve of an LED (data logging with a USB-Cassy)

Experiment:

Today you get to know a new device –
the light-emitting diode (abbr. **LED**).

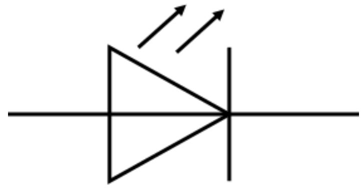


fig. 1: symbol LED

Material:

- 1 electronic source with a voltmeter
- 1 USB-Cassy
- 3 LEDs (red, yellow, green)
- cable
- 470Ω-resistance

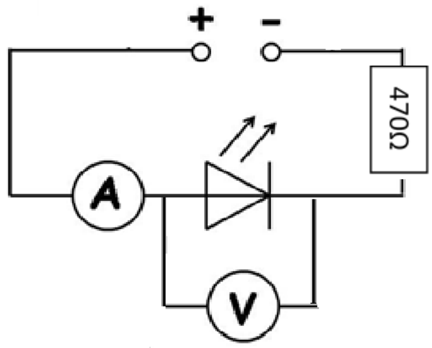


fig. 2: circuit LED

Durchführung:

1. Construct the circuit according to fig. 2.
2. Use the USB-Cassy for the voltmeter and the ampere meter.
3. Watch out for the correct polarity of the LED. The label for cathode and anode is marked on the back of the LED.
4. Meter the conduction current with reference to the voltage of the LED with the help a PC programme (CassyLab). Apply a **maximum of 10V** and make sure that the conduction current of the LED is **not more than 45mA**. Note: If you exceed the given values, you'll ruin the LED!

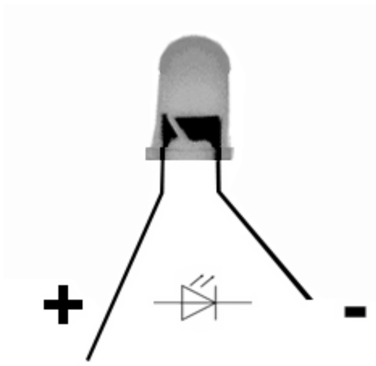
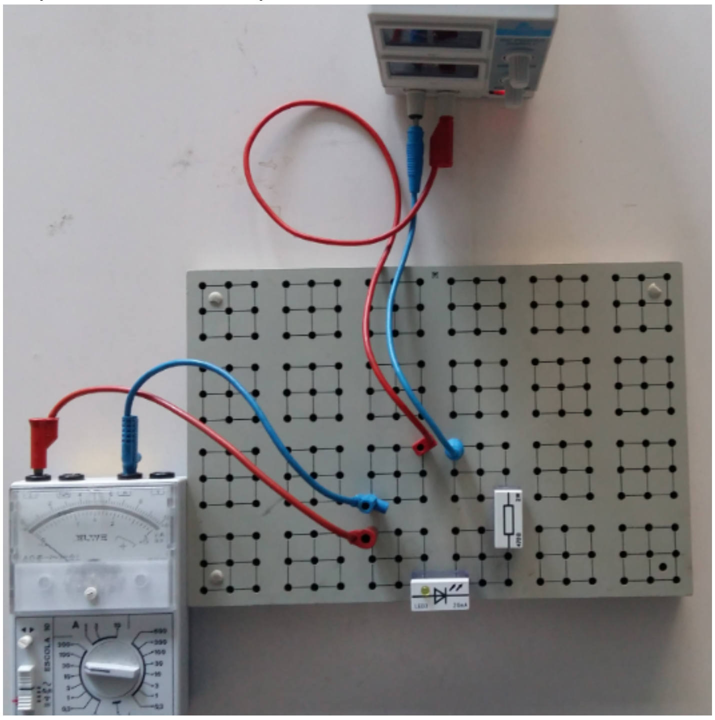


Abb. 3: LED

Student's copy

Solution (analogue data logging)

Experimental setup:

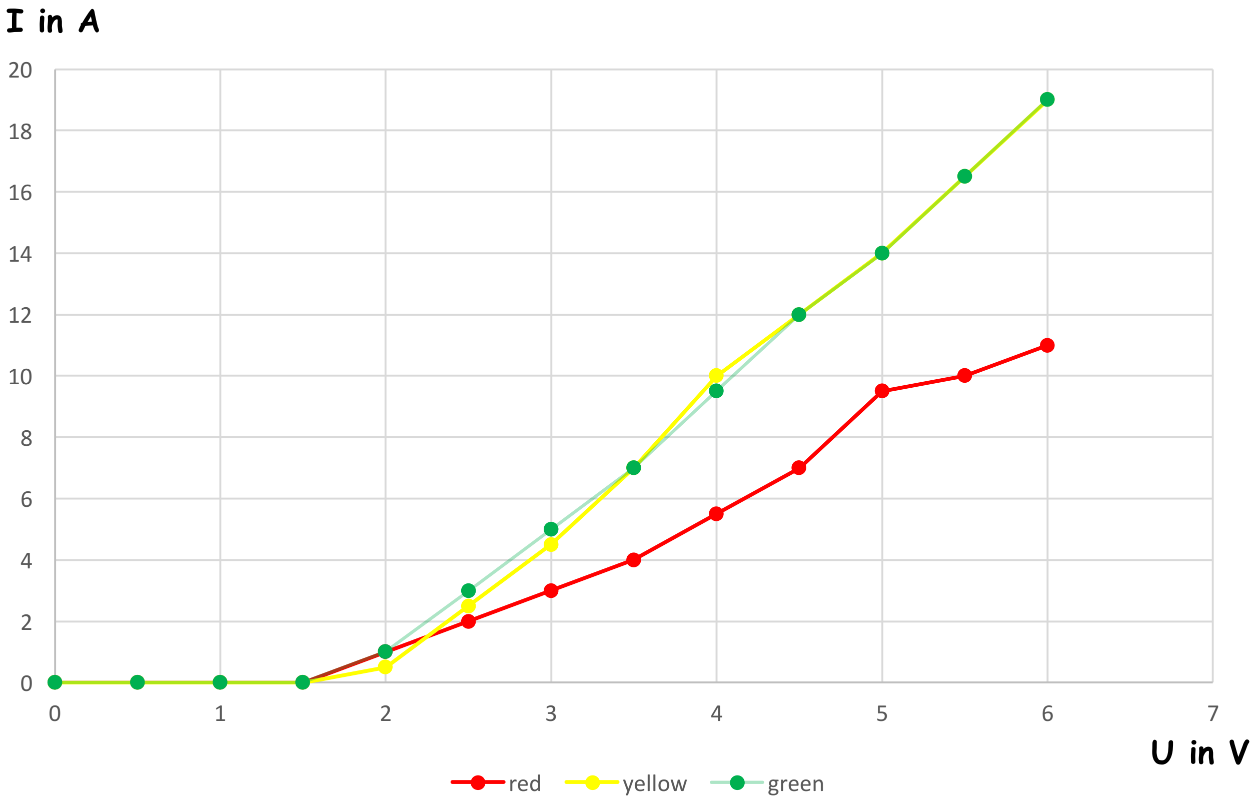


Evaluation:

1. The LEDs illumination depends on a certain threshold voltage U_S. This threshold voltage depends on the colour of the LED.

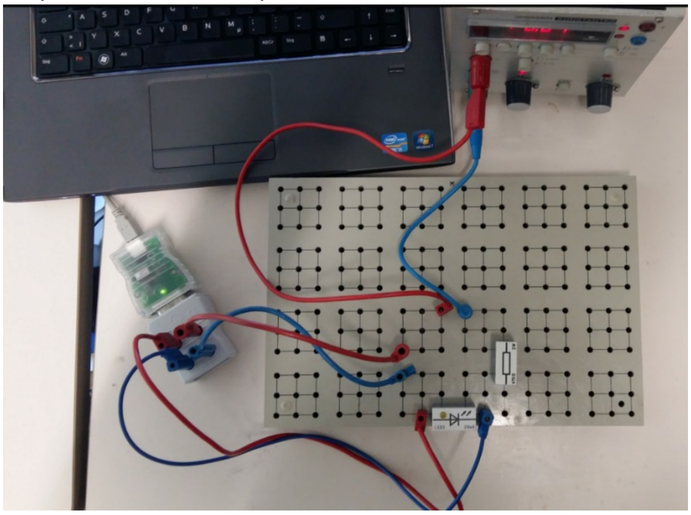
	red	yellow	green
U in V	I in mA	I in mA	I in mA
0	0	0	0
0,5	0	0	0
1	0	0	0
1,5	0	0	0
2	1	0,5	1
2,5	2	2,5	3
3	3	4,5	5
3,5	4	7	7
4	5,5	10	9,5
4,5	7	12	12
5	9,5	14	14
5,5	10	16,5	16,5
6	11	19	19

U-I-characteristic curves of the LEDs

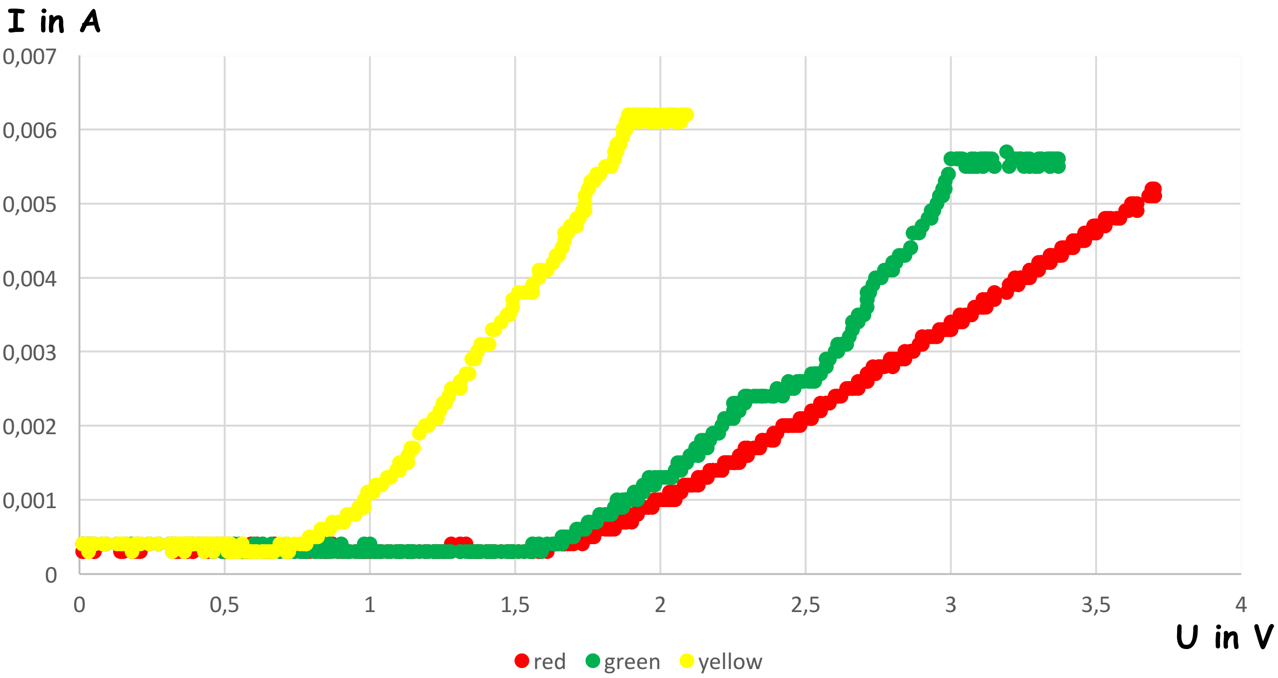


Solution (data logging with USB-Cassy)

Experimental setup:



U-I-characteristic curves of the LEDs (Cassy)



Topic 9: The disappearing glass - Student Worksheet

SUBJECT	LİGHT REFRACTİON AND REFLECTİON
PURPOSE OF THE EXPERİMENT	Analyzing the light refraction and reflection on the objects which do not have source of light.
MATERİALS	A big and a small beakers, a glass strap,a metal strap and baby oil.



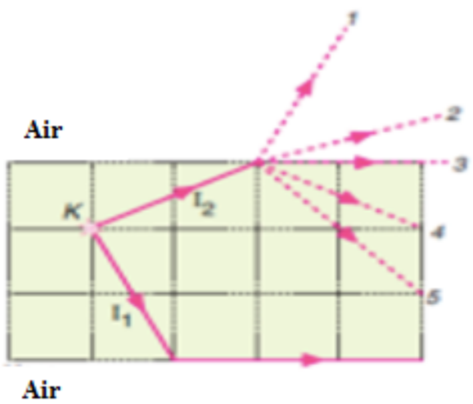

THEEXPERİMENT	Put the small beaker inside the big one and fill it with baby oil until it expires.Add baby oil right until between two beakers are filled up.After that observe if the small beaker is visible from the top and sideways.Then put the straps(glass and metal) and try to observe which one is visible or not..

Student’s copy

RESULTS OF THE EXPERİMENT AND YOUR VİEWS

QUESTIONS :

1.

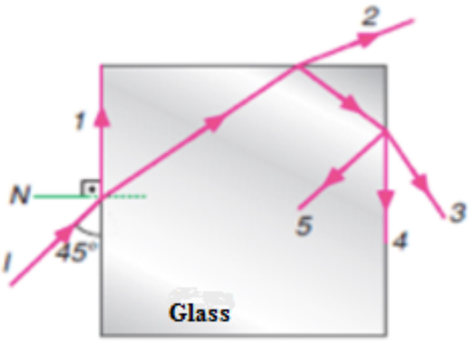


This object shaped as a rectangle has a single colored punctate source of light (K). I_1 beam (that comes from K) follows the way which is given at the image. According to that knowledge which way I_2 beam follows?

Student's copy

2.

Single colored I beam comes to the glass surface from the air occasion. If the limitation degree for glass and air is 45, which way does the beam follows?



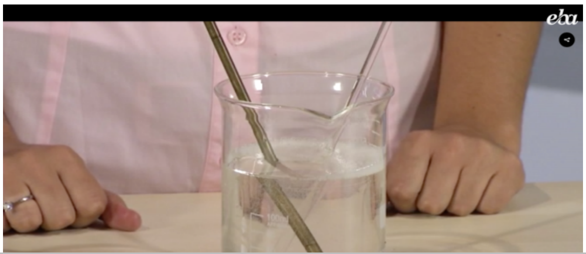
Student's copy

Topic 9: The disappearing glass - Teacher Worksheet

SUBJECT	LİGHT REFRACTİON AND REFLECTİON
PURPOSE OF THE EXPERİMENT	Analyzing the light refraction and reflection on the objects which do not have source of light.
MATERİALS	A big and a small beakers, a glass strap,a metal strap and baby oil.





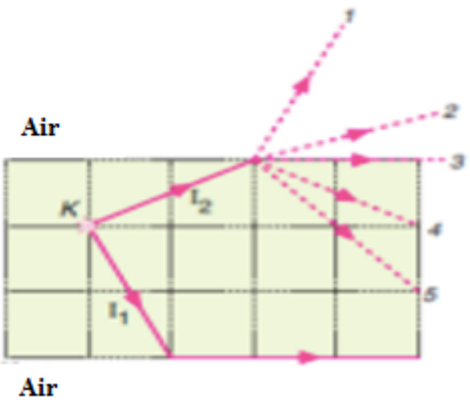


When between two beakers are filled with baby oil,the small one is invisible in profile.Likewise, when the metal and glass strips are put in the beakers,the glass one is relatively invisible than the metal one.In case you look from the top, you can see the brim and body of the small beaker.
So we can say that, for us to see objects that don't have source of light. beams that are coming from light source have to reach our eye by reflecting.Why the small one was invisible is because there weren't any light beams coming to our eyes.
Refractive index of the baby oil is very close to the glass beaker's.In this experiment,baby oil treated like glass.So the small beaker and glass strap became invisible.
If the light beams come across with a different occasion, they will reflect and refract in every limitation of occasions it comes across.And that explains why the small beaker was more visible from above.

Teacher's copy

THE EXPERİMENT	Put the small beaker inside the big one and fill it with baby oil until it expires.Add baby oil right until between two beakers are filled up.After that observe if the small beaker is visible from the top and sideways.Then put the straps(glass and metal) and try to observe which one is visible or not..

QUESTIONS :
1.



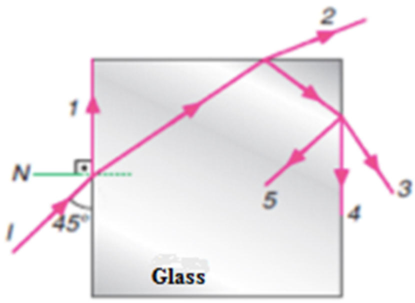
This object shaped as a rectangle has a single colored punctate source of light (K). I_1 beam (that comes from K) follows the way which is given at the image.

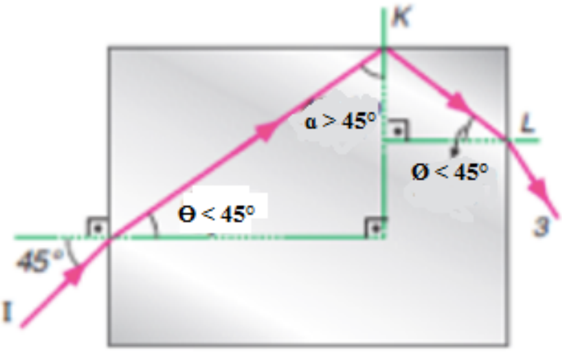
According to that knowledge which way I_2 beam follows?

On passing to the air from transparent object,according to the way that I_1 beam follows we can call the limitation degree as ‘a’.I_2 beam’s coming degree to the air occasion is bigger than ‘a’.So it fully reflects,comes back where it is coming from and follows way 4.

Teacher’s copy

2.





Single colored I beam comes to the glass surface from the air occasion. If the limitation degree for glass and air is 45, which way does the beam follows?

Normally the light which enters the prism from the air refracts by getting close.Coming degree of the light that falls to the point K is bigger than the limitation degree.That's why it falls to the point L than.And this time it gets out by moving away because it's coming degrees smaller than limitation degree at point L.

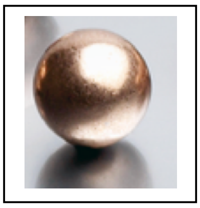
Teacher's copy

Topic 10: Gauss Rifle - Student Worksheet

Source	**11th Class Textbook**
Topic	**Electricity and Magnetism**
Name of The Experiment	**GAUSS RIFLE**

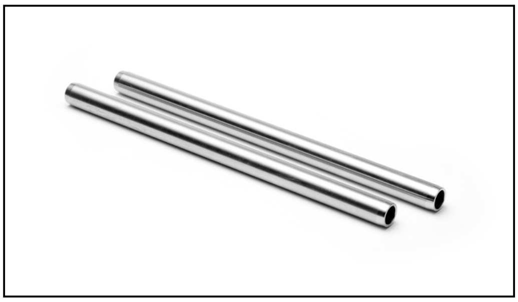
EXPERIMENT MATERIALS

- Identical 6 iron marble

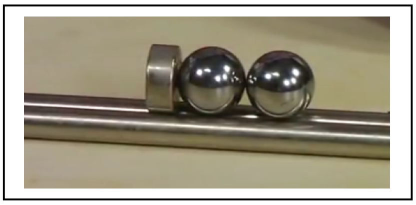


- Brass marble which has the same mass as the iron marbles

- 3 identical Neodymium magnet
- 2 rails wich are made of iron bar



EXPERIMENT STAGES



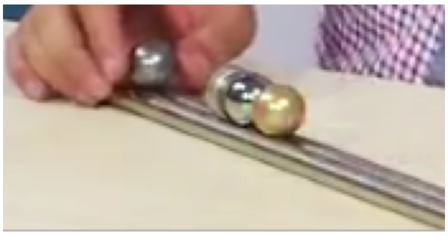
- ✓ 2 marbles are placed in front of the neodymium magnet.

Student's copy

- ✓ An iron marble is released without initial velocity from nearby of neodymium magnet.

- ✓ Brass marble isn't pullet by magnet. Because of the absence of feromagnetic matter.

- ✓ Does the brass marble leave the system with the same speed with iron marble



- ✓ What did you observe?

____

____

____

- ✓ Let's increase the number of magnets and marbles in the system.

Student's copy

✓ What did you observe?

____

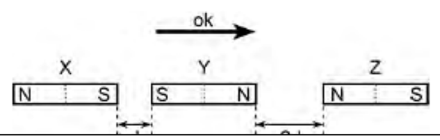
____

____

____

QUESTIONS

1-)



Identical X, Y, Z bar magnets are held in a stationary position as demonstrated above on a horizontal plane without friction.
If there of magnets are deallocated at the same time which of them stars moving arrow direction? (The magnetic field of the ground is nominal)

A) Only X B) Only Y C) Only Z

D) X and Y E) Y and Z

2-)

How does the interaction force change when the force between two point charges is reducet by half?

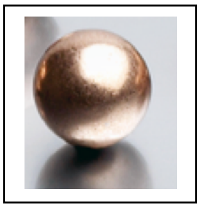
Student’s copy

Topic 10: Gauss Rifle - Teacher Worksheet

Source	**11th Class Textbook**
Topic	**Electricity and Magnetism**
Name of The Experiment	**GAUSS RIFLE**

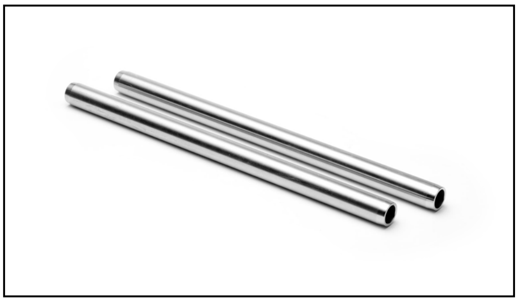
EXPERIMENT MATERIALS

- Identical 6 iron marble
- Brass marble which has the same mass with iron marble



- 3 identical Neodymium magnet

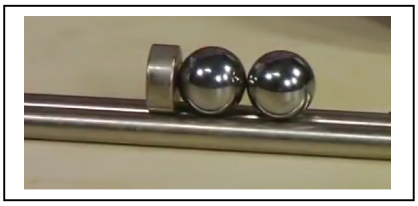
- 2 rails wich are made of iron bar



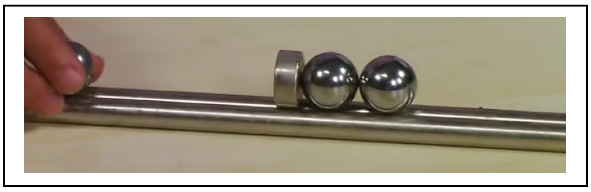
Teacher’s copy

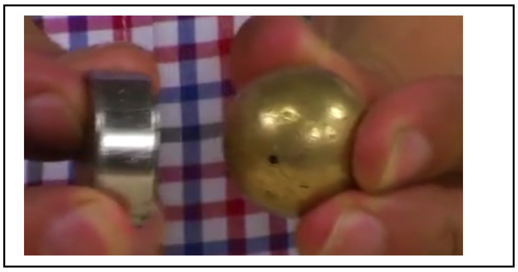
EXPERIMENT STAGES

✓ 2 marbles are placed in front of the
✓ neodymium magnet.

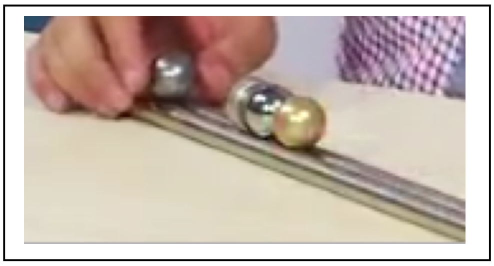


✓ An iron marble is released without initial velocity from nearby of neodymium magnet.





✓ Brass marble isn’t pullet by magnet. Because of the absence of feromagnetic matter.



✓ Does the brass marble leave the system with the same speed with iron marble

✓ What did you observe?

Bras marble isn’t a ferromagnetic matter so it is not pulled by magnet. For this reason, it’s speed is lower than the speed of iron marble.

Teacher’s copy

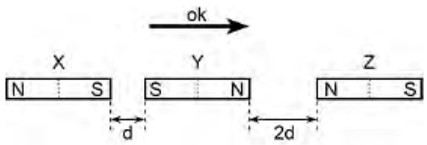
✓ Let's increase the number of magnets marbles in the system.

✓ What did you observe?

At the second stage of the observation we saw that the speed of last marble was higher than the one in the 1st stage, since the number the magnets and marbles are in creased and the distance between them is reduced.

QUESTIONS

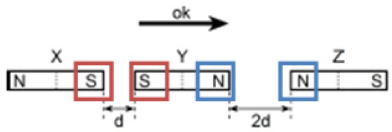
1-)



Identical X, Y, Z bar magnets are held in a stationary position as demonstrated above on a horizontal plane without friction.
If there of magnets are deallocated at the same time which of them stars moving arrow direction? (The magnetic field of the ground is nominal)

A) Only X B) Only Y C) Only Z

D) X and Y E) Y and Z



Since the same poles push each other, the Y and Z magnets will move in the direction of the arrow.
Correct answer: E

Teacher's copy

2-) How does the interaction force change when the force between two point charges is reducet by half?

If the distance between charges is 'r' at the beginning, then it will become 'r/2' after it is reduced by half

Figure 03.45: The charges with r and r/2 distances.

Then if we write the interaction forces;

$$F = k.\frac{q_1 . q_2}{r^2}$$
$$F' = k.\frac{q_1 . q_2}{\left(\frac{r}{2}\right)^2}$$

F we divide these interaction forces;

$$\frac{F}{F'} = \frac{k.\frac{q_1 . q_2}{r^2}}{k.\frac{q_1 . q_2}{\left(\frac{r}{2}\right)^2}}$$
$$\frac{F}{F'} = \frac{\frac{1}{r^2}}{\frac{1}{\frac{r^2}{4}}}$$
$$\frac{F}{F'} = \frac{1}{r^2} . \frac{r^2}{4}$$
$$\frac{F}{F'} = \frac{1}{4} \text{ yani } F = \frac{1}{4}F'$$

This means F': 4F so if the distance reduced by half then the interaction force incrases 4 time.

Teacher's copy

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"Moving forward with key competences"

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Eötvös József Gimnázium és Kollégium, Tata - **Hungary**

Clemens-August-Gymnasium Cloppenburg - **Germany**

Liceo "Bocchi-Galilei" Adria - **Italy**